DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
GREAT LAKES REGION
CHICAGO, ILLINOIS

Specification No. FAA-GL-2989
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Specification for HVAC Control Upgrade at the Hector International Airport Traffic Control Tower, Fargo, North Dakota.

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DIVISION 1 - GENERAL REQUIREMENTS

1A SCOPE OF WORK: This project consists of upgrade existing HVAC controls with an open system programming platform, utilizing open platform front-end software designed with LonWorks architecture and LonMark field devices. LonWorks architecture is based on open protocol technology and shall provide flexibility when integrating a multi-vendors system. The open platform front-end software, such as Circon Visual Integrator 3, utilizing LNS database and LNS Network Tool, such as Circon Network Integrator, shall provide easy navigable graphical interface to make possible program changes, installation modifications, and provide system maintenance. This includes removal of existing but non-useable hardware, all design, engineering, equipment, installation, final checkout, documentation and two separate training sessions for a total of eight (8) personnel shall be coordinated with the facility through the resident engineer. Call support shall be available throughout the one-year warranty period. A laptop computer, desktop computer, monitor and printer will be provided by the government to allow local control and software allow for remote access.

Front-end installation shall include : software and appropriate licenses, router, monitor, desktop computer, laptop computer and printer.

Provide air and water Testing and Balancing services so spaces will have designed air flow rate and temperature, and humidity.

Maintain uninterrupted overall operation of the facility during the Direct Digital Control upgrade, such as comfort ventilation in the Tower and cooling of Control Cab and electronic equipment. If interruption is necessary, provide temporary provisions to maintain operation of the Tower during regular hours of occupancy, otherwise provide work during off hours. Coordinate this with the Tower SSC manager through the resident engineer.

The Tower second floor outside air intake hoods have water leak. They shall be extended down for an additional 24” to prevent rain drifting into the first floor wall and workbench.

1B SCHEDULE OF WORK AND RESTRICTIONS: The contractor shall submit a work schedule for approval prior to beginning work. Work hours throughout the existing building shall be coordinated with the FAA Resident Engineer. Normal working hours are between 7:30 AM and 4:00 PM weekdays.

Removal of the existing Trane Tracer Summit shall not take place until the new direct digital control system have been delivered to the job site and are ready for installation. Location for storage of materials will be determined by the Resident Engineer.

Temporary heating and air conditioning shall be provided to maintain the space temperature at 72F during the system upgrade.

1C COORDINATION: All contacts between the contractor and the FAA shall be coordinated through the FAA Resident Engineer.

1D CLEANUP: Each day the contractor shall remove all rubbish, dirt, and debris as it accumulates during the process of work. At completion of the work, all areas shall be cleaned and all obstructions and surplus material shall be removed.

1E INGRESS AND EGRESS TO WORK AREAS: Ingress and egress to the work areas shall be as directed by the Resident Engineer. Security precautions against unauthorized facility entrance shall be maintained.

1F CONTRACTOR'S LIABILITY: Damage to the existing facility or equipment shall be reported to the Resident Engineer without delay. The contractor shall be responsible for repairing or having repaired all damaged areas to the facility or equipment directly caused by contractor related work. All repairs shall be accomplished, without delay, at the contractor's expense to the satisfaction of the Resident Engineer. After notice to proceed and prior to the commencement of construction, the contractor and the Resident Engineer shall conduct joint inspections of the existing areas affected by the construction. Damage or defects shall be noted and will be used as the basis for determination of damages caused by the contractor's operations.

1G PRE-CONSTRUCTION MEETING: The contractor shall attend a pre-construction meeting at the job site prior to start of work.

1H FIRE EXTINGUISHING EQUIPMENT: The contractor shall have an equivalent of 2-20 lb. class A and B fire extinguishers in the work area through the progress of the job. CO_2 type fire extinguishers are acceptable.

1I DEMOLITION: All material to be removed shall be removed such that it would not effect or damage any existing equipment or structure. All waste material shall be hauled and be placed in a dumpster or removed from the premises each day. The existing control units shall be legally disposed of by the contractor.

1J CONTRACTOR'S WARRANTY: The contractor shall guarantee all materials and workmanship under this contract against defects or incorrect installation for a period of one year from the date of the Government acceptance of work. Repair or replacement of any defective materials, correction of faulty workmanship, or correction of any item not in accordance with the manufacturer's specifications or directions and these specifications shall be made at the contractor's expense.

1k COMPLETE INSTALLATION: Contractor shall provide all labor, materials, equipment necessary for a complete HVAC DIRECT DIGITAL CONTROL installation.

1L SITE VISIT: Mandatory Site Visit information on SIR.

13801

UTILITY MONITORING AND CONTROL SYSTEM (UMCS)

PART 1 GENERAL

1.01 SYSTEM DESCRIPTION

A. The Utility Monitoring and Control System (UMCS) shall perform supervisory control and monitoring of a basewide LonWorks network using LonWorks Network Services (LNS) as specified and shown. The UMCS shall interface to local LonWorks building controls installed per Section 15951 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS, as well as existing legacy systems. The UMCS shall maintain the LNS database(s) for the entire network.

B. System Requirements
1. The Contractor shall furnish a UMCS in accordance with UL 916 and with the following characteristics:
a. The UMCS shall include an IP network as shown and specified and shall interface to building level control networks using ANSI-709.1 to IP Routers or IP Routers as specified.
b. The system shall provide a user interface and shall perform supervisory monitoring and control functions as specified.
c. All software used by the UMCS shall be licensed to the installation, and shall be provided to the installation as specified.
d. All necessary documentation, configuration information, configuration tools, programs, drivers, and other software shall be licensed to and otherwise remain with the government such that the government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the contractor.
e. The contractor shall provide sufficient documentation and data, including rights to documentation and data, such that the government or their agents can execute work to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the contractor.
f. All communication between the UMCS and building netwtorks shall via the ANSI/EIA 709.1B protocol over the IP network in accordance with ANSI/EIA 852.

C. Symbols, Definition and Abbreviations
1. Symbols, definitions, and engineering unit abbreviations used in information displays, submittals and reports shall be as shown in the contract drawings. Symbols, definitions and abbreviations not in the contract drawings shall conform at a minimum to IEEE 100 and ASHRAE Handbook, as applicable.

D. System Units and Accuracy
1. System displays, print-outs and calculations shall be performed in English (inch-pound) units. Calculations shall have accuracy equal to or exceeding sensor accuracy as specified in Section 15951 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS. Displays and printouts shall have precision and resolution equal to or exceeding sensor accuracy as specified in Section 15951 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS.

1.02 RELATED WORK

A. Refer to Section 15951 DIRECT DIGITAL CONTROL FOR HVAC
B. Refer to NFPA 70, National Electric Code (Latest Edition)

1.03 SUBMITTALS

A. Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.

B. Technical data packages consisting of technical data and computer software (meaning technical data which relates to computer software) which are specifically identified in this project and which may be defined/required in other specifications shall be delivered strictly in accordance with the CONTRACT CLAUSES and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered shall be identified by reference to the particular specification paragraph against which it is furnished. All submittals not specified as technical data packages are considered 'shop drawings' under the Federal Acquisition Regulation (FAR) and shall contain no proprietary information and shall be delivered with unrestricted rights.

C. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES, the CONTRACT CLAUSES and DD Form 1423 and according to the timing specified in paragraph PROJECT TIMING:

SD-02 Shop Drawings

UMCS Contractor Design Drawings; G
Final As-Built Drawings; G

SD-03 Product Data

Product Data Sheets; G

Copies of all manufacturer catalog cuts and specification sheets for all products (equipment) specified in PART 2 and supplied under this contract shall be submitted. The cuts and specification sheets shall be in a bound, indexed volume organized by equipment type and manufacturer.

Computer Software; G

Computer software which are specifically identified in this project, and which may be defined/required in other specifications, shall be delivered as a Technical Data Package, strictly in accordance with the CONTRACT CLAUSES, and in accordance with the Contract Data Requirements List, DD Form 1423. Manuals for all software identified in this project shall be submitted with the software.

SD-05 Design Data

Network Bandwidth Usage Calculations; G

SD-06 Test Reports

Factory Test Report; G

The Factory Test Report shall be submitted as a Technical Data Package.

Start-Up and Testing Report; G

Contractor shall submit a Start-Up and Testing Report certifying that the system has been tested and is functioning properly. The Start-Up and Testing report may be submitted as a Technical Data Package.

PVT Phase I Procedures; G

PVT Procedures may be submitted as a Technical Data Package.

PVT Phase I Report; G

PVT Phase I Report may be submitted as a Technical Data Package.

PVT Phase II Report; G

PVT Phase II Report may be submitted as a Technical Data Package.

SD-10 Operation and Maintenance Data

Preventive Maintenance Work Plan; G

Basic Operator Training Documentation; G

Training manuals for Basic Operator Training shall be delivered for each trainee on the Course Attendance List with 2 additional copies delivered for archival at the project site.

Advanced Operator Training Documentation; G

Training manuals for Advanced Operator Training shall be delivered for each trainee on the Course Attendance List with 2 additional copies delivered for archival at the project site.

Operator Refresher Training Documentation; G

Training manuals for Operator Refresher Training shall be delivered for each trainee on the Course Attendance List with 2 additional copies delivered for archival at the project site.

Operation and Maintenance (O&M) Manual; G

Contractor shall prepare and submit 3 bound O&M Manuals and 3 copies of the manual in PDF format on CD-ROM. Bound manuals shall be indexed and tabbed. Manuals in PDF form shall be a single PDF file, or multiple PDF files with a table of contents containing links to the other files.

1.04 OPERATION AND MAINTENANCE (O&M) MANUAL

A. The UMCS Operation and Maintenance manual shall include:
1. HVAC control system sequences of operation.
2. Procedures for the UMCS system start-up, operation and shut-down.
3. Final As-Built UMCS system detail drawings.
4. Routine maintenance checklist. The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all installed devices, the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference.
5. Qualified service organization list.
6. Start-Up and Testing Report.
7. Performance Verification Test (PVT) Procedures and Reports.

1.05 MAINTENANCE AND SERVICE

A. The Contractor shall provide inspections and associated preventive maintenance, repair, normal and emergency service calls, labor, supervision, tools, materials, software, equipment, transportation, and management necessary, for the UMCS network hardware, computer hardware, computer software, printers, UPS, and other peripherals described in PART 2: PRODUCTS of this specification. This work includes inspection, testing, cleaning, and part or component replacement as specified. Work includes providing necessary preventive and unscheduled maintenance and repairs to keep the UMCS operating as specified, and accepted by the Government, and other services as specified. Work shall comply with manufacturer's recommendations and industry standards. The Contractor shall provide technical support via telephone during Contractor's regular working hours.

B. Work Coordination
1. The Contractor shall schedule and arrange work to cause the least interference with the normal Government business and mission. In those cases where some interference may be essentially unavoidable, the Contractor shall coordinate with the Government to minimize the impact of the interference, inconvenience, equipment downtime, interrupted service and personnel discomfort.
2. Work Control

a. The Contractor shall implement work control procedures to ensure timely accomplishment of work requirements, as well as to permit tracking of work in progress. The Contractor shall plan and schedule work to ensure material, labor, and equipment are available to complete work requirements within the specified time limits and in conformance with the specifications. Verbal scheduling and status reports shall be provided when requested by the Government. Work shall meet the specified standards, and comply with manufacturer's recommendations and industry standards. The Contractor shall comply with user, local, state and federal standards and applicable building and safety codes.

b. When the Contractor completes work on a system or piece of equipment, that system or piece of equipment shall be free of missing components or defects which would prevent it from functioning as originally intended and designed. Corrective or repair/replacement work shall be completed, including operational checks and cleanup of the job site. Replacements shall conform to the same specifications as the original equipment. During and at completion of work, debris shall not be allowed to spread unnecessarily into adjacent areas nor accumulate in the work area itself. Such debris, excess material, and parts shall be cleaned up and removed at the completion of the job and/or at the end of each day that work is in progress.

C. Equipment Repairs

1. Equipment repairs shall be initiated and completed within the following time periods following first notification:

a. for non-redundant computer server hardware, initiate within 4 hours and complete within 8 hours

b. for non-redundant computer workstation hardware, initiate within 4 hours and complete within 8 hours

c. for redundant computer server hardware, initiate within 36 hours and complete within 5 days

d. for redundant computer workstation hardware, initiate within 2 days and complete within 5 days

e. for active network hardware, initiate within 4 hours and complete within 6 hours

f. for cabling and other passive network hardware, initiate within 16 hours and complete within 5 days.

Repair is the restoration of a piece of equipment, a system, or a facility to such condition that it may be effectively used for its designated purposes. Repair may be overhaul, reprocessing, or replacement of nonfunctional parts or materials that have failed or deteriorated by action of the elements or usage and have not been corrected through maintenance, or replacement of the entire unit or system if beyond economical repair.

D. Replacement, Modernization, Renovation

1. The Government may replace, renovate, or install new equipment at Government expense and by means not associated with this contract. Replaced, improved, updated, modernized, or renovated systems and equipment interfaced to the system may be added to the Contractor's maintenance and service effort as a modification.

E. Access To UMCS Equipment

1. Access by the Contractor shall be in accordance with the following:

a. The Contractor shall be responsible for coordinating access to facilities and arranging that they be opened and closed during and after the accomplishment of the work effort. The Contractor should allow approximately 30 minutes delay time per access to each security controlled or locked facility. For Contractor access to a controlled facility the Contractor shall contact the Government for assistance. Service calls must be completed within the time limits specified unless the cause of the problem is determined to be in UMCS equipment located within the controlled or locked facility which required a delay to obtain entry, in which case the required response time will be extended by the amount of time access to the controlled facility was denied.

b. The Government may provide keys for access to UMCS equipment where the Government determines such key issuance is appropriate. The Contractor shall establish and implement methods of ensuring that keys issued to the Contractor by the Government are not lost or misplaced, are not used by unauthorized persons, and are not duplicated. The Contractor shall develop procedures covering key control that shall be included in the quality control plan.

F. Records, Logs, and Progress Reports

1. The Contractor shall keep records and logs of each task, and shall organize cumulative records for each major component and for the complete system chronologically. A continuous log shall be maintained for the UMCS. The log shall contain initial analog zero and span calibration values. Complete logs shall be kept and shall be available for inspection on site, demonstrating that planned and systematic adjustments and repairs have been accomplished for the UMCS.
   a. Service Call Reporting Requirements: The Contractor shall complete a service call work authorization form for each service call by close of business on the day when the service is completed.
   b. Maintenance Reporting Requirements: The Contractor's progress reports shall include:
      1) Service call work authorization and completion forms (Emergency Service Call) to be delivered weekly.
      2) Service call work authorization and completion forms (Normal Service and Emergency Service Call) to be delivered monthly.
      3) Telephone consultation log to be delivered monthly.

G. Preventive Maintenance Requirements: The Contractor shall perform maintenance procedures as described below, or more often if required by the equipment manufacturer.

1. Preventive Maintenance Work Plan
   a. The Contractor shall prepare a Preventive Maintenance Work Plan to schedule all required preventive maintenance. Government approval of the Work Plan shall be obtained as specified in paragraph PROJECT TIMING. The Contractor shall strictly adhere to the approved work plan to facilitate Government verification of work. If the Contractor finds it necessary to reschedule maintenance, a written request shall be made to the Government detailing the reasons for the proposed change at least five days prior to the originally scheduled date. Scheduled dates shall be changed only with the prior written approval of the Government.
   b. Semiannual Maintenance
      1) Clean Computer Hardware.
      2) Run system diagnostics and correct diagnosed problems.
      3) Perform fan checks and filter changes for UMCS hardware.
      4) Perform all necessary adjustments on printers.
      5) Resolve all outstanding problems.
      6) Install new ribbons, ink cartridges and toner cartridges into printers, and ensure that there is at least one spare ribbon or cartridge located at each printer.
   c. Maintenance Procedures
      1) Maintenance Coordination: Any maintenance event that results in component downtime shall be coordinated with the Government as follows:
         (a) for non-redundant computer server hardware, provide 14 days notice, components shall be off-line for no more than 8 hours
         (b) for non-redundant computer workstation hardware, provide 7 days notice, components shall be off-line for no more than 8 hours
         (c) for redundant computer server hardware, provide 7 days notice, components shall be off-line for no more than 36 hours
         (d) for redundant computer workstation hardware, provide 4 days notice, components shall be off-line for no more than 48 hours
         (e) for active network hardware, provide 14 days notice, components shall be off-line for no more than 6 hours
         (f) for cabling and other passive network hardware, provide 21 days notice, components shall be off-line for no more than 12 hours.
      2) Computer Workstations and Servers: The Contractor shall run utilities to verify the structure and consistency of the hard disk file systems, performed on each disk. The Contractor shall perform a complete backup of the system prior to running diagnostics; this backup shall be performed with the system online.
      3) Printer: Printer maintenance shall include required lubrication and cleaning of the printing mechanism and the cleaning of the case, replacement of the ribbon or printing cartridge, complete testing and documentation. All work and material which is necessary for the printer to function properly shall be provided.
      4) Software/Firmware: Software/firmware maintenance shall include operating systems, application programs, and files required for the proper operation of the UMCS regardless of storage medium. User developed software is not covered

by this contract, except that the UMCS software/firmware must be maintained to allow user creation, modification, deletion, and proper execution of such user-developed software as specified. Software/firmware must be maintained to fully perform functions as specified in the manufacturer's documentation. The Contractor shall perform diagnostics and corrective reprogramming as required to maintain total UMCS operations as specified. The Contractor shall back up software before performing any computer hardware and software maintenance. In order to maintain the software/firmware in accordance with the requirements of this contract, the Contractor may provide and install software/firmware updates at the Contractor's expense upon obtaining written approval from the Government. Software/firmware updates and other modifications shall not degrade the performance or decrease the functionality of any part of the UMCS, and shall be provided with the same Rights in Technical Data and Computer Software as the original software/firmware. Documentation and magnetic media shall be modified to reflect the updates and modifications. The Contractor shall not modify any database parameters without approval from the Government. Any approved changes and additions to the database shall be properly documented, and the appropriate manuals shall be updated.

5) Network: Network maintenance shall include testing transmission media and equipment to verify signal levels, system data rates, errors and overall system performance.

H. Service Call Reception

1. The Contractor shall have procedures for receiving and responding to service calls 24 hours per day, seven days a week, including weekends and holidays. A single telephone number shall be provided by the Contractor for receipt of service calls during regular working hours. For service calls after regular working hours, the Contractor may provide a calling list of no more than three telephone numbers; the Contractor may alternatively provide a pager telephone number. Telephone calls shall be answered within 30 seconds, or pager calls returned within 10 minutes, by an individual fully familiar with the maintenance and service procedures. Service calls shall be considered received by the Contractor at the time and date the telephone call is placed by the authorized Government representative.
2. The Contractor shall separately record each service call request, as received. The form shall include the serial number identifying the component involved, its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. The Contractor shall complete a service call work authorization form for each service call.
3. The Contractor shall respond to each service call request within two working hours. The status of any item of work must be provided within four hours of the inquiry during regular working hours, and within 16 hours after regular working hours. Response time is defined as the time allowed the Contractor after initial notification of a work requirement to be physically on the premises at the work site with appropriate tools, equipment, and materials, ready to perform the work required.
4. A Government representative will advise the Contractor by phone or in person of all maintenance and service requests, as well as the classification of each based on the definitions specified. A description of the problem or requested work, date and time notified, location, classification, and other appropriate information will be placed on a Service Call Work Authorization Form by the Government and made available for pickup by the Contractor, or sent via fax to the Contractor by 12 noon the following Government workday.

I. Service Call Work Warranty

1. The Contractor shall provide a 1 year unconditional warranty on service call work. The warranty shall include labor and material necessary to restore the equipment involved in the initial service call to a fully operable condition. In the event that Contractor service call work causes damage to additional equipment, the Contractor shall be liable for labor and material to restore the system to full operation. Contractor response to service call warranty work shall be the same as required by the initial service call.

J. System Modifications

1. The Contractor shall make recommendations for system modification in writing to the Government. No system modifications shall be made without prior approval of the Government. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other

documentation affected. The Contractor shall make available to the Government operating and application software updates during the life of this contract. The Government will notify the Contractor if the updates can be installed. Maintenance releases of the UMCS system software shall be provided at no additional cost to the Government. These updates shall be accomplished in a timely manner, fully coordinated with the Government, and shall be incorporated into the operations and maintenance manuals, and software documentation. There shall be at least one scheduled update near the end of the contract period, at which time the Contractor shall make available the latest released version of the Contractor's software, and shall install and validate it upon approval by the Government..

K. Telephone Consultation and Remote Software Service

1. The Contractor shall provide up to 48 hours per year of telephone consultation to Government personnel. The Government will initiate telephone consultation calls during regular working hours for the purposes of identifying and resolving apparent operational problems with the UMCS. The Contractor shall provide personnel fully familiar with the subject matter of the Government initiated call. Approximately 60% of telephone consultation will require a skill level equivalent to a system analyst, and approximately 40% of the telephone consultation will require a skill level equivalent to a computer programmer. The Contractor shall keep a log of the dates, times, names of Government personnel, and duration of each call, and shall advise the designated Government personnel when more than 4 hours of consultation time has been expended in any month. The Contractor shall not provide over 4 hours of consultation per month without authorization from the Government. The Contractor shall submit a copy of the log to the Government each month.

1.06 UMCS Network

A. The UMCS network shall provide end-to-end transmission speeds of at least 100 MBPS using the IP protocol. The Bit Error Rate (BER) of the data communications components shall be no greater than one error in 10E-9 for end-to-end subsystems.

B. The UMCS Network shall support ANSI/EIA-709.1B communications in accordance with ANSI/EIA-852 and all other necessary UMCS functionality. The Network shall use the following protocols for layers 1 through 7 as defined in the ISO OSI Model:

1. OSI Layer 1. The physical layer shall be in conformance with IEEE 802.3 and operate at least 100 megabits per second Mbps (100Base-T and 100Base-FX). Higher speed protocols may be used. If higher speed physical layers are used, bridging hardware shall be provided to ensure compatibility with 100 Mbps devices.
2. OSI Layer 2. The data-link layer shall be the IEEE 802.2 Logical Link Control (LLC), Type 1, Class 1, in combination with the IEEE 802.3 Protocol.
3. OSI Layer 3. The network layer shall be the Internet Protocol (IP; RFC 791), the Internet Control Message Protocol (ICMP; RFC 792), and the Address Resolution Protocol (ARP; RFC 826).
4. Layers 4 - 7. Network shall support all layer 4 protocols supported by IP (RFC 791) including but not limited to ICMP (RFC 792), IGMP (RFC 1112), TCP (RFC 793), UDP (RFC 768), IGP, GRE (RFC 2784) and protocols required by ANSI/EIA-852.

PART 2 PRODUCTS

2.01 EQUIPMENT REQUIREMENTS

A. Product Certifications

1. Computing devices, as defined in 47 CFR 15, supplied as part of the UMCS shall be certified to comply with the requirements of Class B computing devices.

B. Product Sourcing

1. Contractor supplied units of the same type of equipment shall be products of a single manufacturer. Each major component of equipment shall have the manufacturer's name and address, and the model and serial number in a conspicuous place. Materials and equipment shall be new standard unmodified products of a manufacturer regularly engaged in the manufacturing of such products.

C. Environmental Requirements

1. The contractor shall provide components which will operate under the following environmental conditions:
   a. That portion of the data communications equipment system installed indoors shall operate properly in a controlled environment with ambient temperatures between +50 and 95 degrees F and ambient relative humidity between 10% and 85% noncondensing.
   b. Electrical Power from 100 to 125 volts AC (VAC), 60 Hz, single phase, three wire with a three-pronged, dedicated circuit outlet.
   c. The equipment shall meet NFPA 70, UL 478, UL 910, FCC EMC, MIL-STD-454N Requirements, and FCC Part 15.

D. Product Data Sheets
1. For each product specified in this contract manufacturer catalog cuts and sheets which indicate conformance to product requirements shall be available and shall be submitted as specified.

2.02 NETWORK HARDWARE

A. Nameplates
1. Laminated plastic nameplates shall be provided for all network hardware. Each nameplate shall identify the function, network address and identifier of the device. Laminated plastic shall be .125 inch thick, white with black center core. Nameplates shall be a minimum of 1x3inches with minimum .25 inch high engraved block lettering. Nameplates for devices smaller than 1x3 inches shall be attached by a nonferrous metal chain. All other nameplates shall be attached to the device in conspicuous location.

B. Building Point of Connection (BPOC) Hardware
1. ANSI-709.3 to IP Router
   a. ANSI-709.3 to IP Routers shall perform layer 3 routing of ANSI/EIA-709.1B packets over an IP network in accordance with ANSI/EIA-852. The router shall provide the appropriate connection to the IP network and connections to the ANSI/EIA-709.3 TF/FT-10 network. ANSI-709.3 to IP Routers shall not rely on the Dynamic Host Configuration Protocol (DHCP) for their IP addresses, and shall be configurable via an ANSI/EIA-852 Configuration Server.
2. ANSI-709.1 Gateway
   a. Gateways shall have the appropriate connection on the building-side (non-ANSI 709.1 side) to interface to the building DDC system, and shall meet the following requirements:
      1) It shall be capable of being installed, configured and programmed for the designated application and through the use of instructions in the manual supplied by the Contractor.
      2) All software required for gateway configuration shall be furnished.
      3) It shall provide protocol translation from the building level control protocol to ANSI/EIA-709.1B.
      4) t shall communicate on the ANSI/EIA-709.1B over an IP network in accordance with ANSI/EIA-852. Contractor may provide a second device co-located with the protocol translator to meet this requirement.
      5) It shall allow binding of its standard network variables(SNVTs).
      6) For the LonWorks network, it shall be capable of transmitting data using the "min. max. and delta" (throttling and heartbeat) methodology.
      7) It shall provide the ability to label SNVTs that are mapped from third party devices.
      8) It shall provide capacity for mapping all required points as shown plus an additional 50% from the legacy side as SNVTs on the LonWorks side.
      9) It shall be capable of supporting polled and synchronous modifiers for network variables.
      10) It shall supply a LonMark external interface file (XIF) as defined in the LonMark XIF Guide for use with LNS tools and utilities.
      11) It shall support have a "service pin" which, when pressed, will cause the Gateway to broadcast its 48-bit NodeID and ProgramID over the network.
      12) It shall provide a configurable self-documenting string.
      13) It shall retain its configuration after a power loss of an indefinite time, and shall automatically return to it's pre-power loss state once power is restored.

C. IP Network Hardware
1. Wire and Cables.

a. Interior LAN Copper Cable: Interior Copper LAN cable shall meet or exceed all requirements of Category 5 cable as specified in ANSI/TIA/EIA-568-A. Terminations, patch panels, and other hardware shall meet or exceed Category 5 specifications and shall be as specified in SECTION 16710A PREMISES DISTRIBUTION SYSTEM. Cabling products shall be tested and certified at frequencies up to at least 100 MHz for use at data speeds up to at least 100 Mbps. Other types of cable commonly used within IEEE 802.3 LANs (e.g., thicknet and thinnet) shall be used only in cases to interconnect with existing coaxial cable plants. Short lengths of coaxial cable and coaxial transceivers may be used in these applications. The contractor shall provide separately orderable cable, taps and connectors.

b. Interior Fiber Optic Cable: Interior Fiber Optic Cable shall be Multimode Fiber, 62.5/125 micron with ST connectors as specified in ANSI/TIA/EIA-568-A. Terminations, patch panels, and other hardware shall be compatible with the specified fiber and shall be as specified in SECTION 16710A PREMISES DISTRIBUTION SYSTEM. The data communications equipment shall use the 850-nm range of multimode. Fiber-optic cable shall be suitable for use with the 100Base-FX standard as defined in IEEE 802.3.

c. Exterior Fiber Optic Cable: Exterior Fiber Optic Cable shall be Multimode Fiber, 62.5/125 micron with ST connectors as specified in ANSI/TIA/EIA-568-A. Terminations, patch panels, and other hardware shall be compatible with the specified fiber and shall be as specified in Section 16713N FIBER OPTIC (FO) OUTSIDE PLANT (OSP) MEDIA. The data communications equipment shall use the 850-nm range of multimode fiber-optic cable. Fiber-optic cable shall be suitable for use with the 100Base-FX standard as defined in IEEE 802.3.

2. Fiber Optic Patch Panel.

a. This unit shall be wall or rack mountable and designed to provide termination facilities for up to 24 fibers. Unit shall also have capability to be equipped with spliced trays, six packs (for adapters), and blank panels for easy termination of the fiber bundles and tube cables. Fiber-optic terminating equipment shall provide for mounting of ST or SC connectors on an optical patch panel. Fiber-cable management and cable-routing hardware shall be provided by the contractor to assure conformance to minimum fiber and cable bend radii. Connectors on the patch panel shall be ST or SC feed through. Access to both sides of the panel shall be provided by the contractor. The patch panel for the connectors shall be mounted to facilitate rearrangement and identification. Each apparatus shall have cabling and connection instructions associated with it. The patch panels shall be either rack or wall mountable.

3. Fiber Optic Media Converter

a. Fiber Optic media converter shall provide media conversion between layer 1 copper and fiber media to support data rates equal to the greater of the physical layer or 100 Mbps as specified in IEEE 802.3.*

4. Ethernet Switch

a. Switches shall be IEEE 802.3 bridges which shall function as the center of a distributed-star architecture and shall be "learning" bridges with spanning tree algorithms per IEEE 802.1D. The switch shall support the connected media types and shall have a minimum of 150% the required ports and no fewer than 4 ports.

5. IP Router

a. The contractor shall provide IP router network equipment. The routers shall be fully configurable for protocol types, security, and routing selection of sub-networks. The router shall meet all requirements of RFC 1812 and I3A.

2.03 COMPUTER HARDWARE

A. Nameplates

1. Laminated plastic nameplates shall be provided for each server and workstation. Each nameplate shall identify the function, network address and identifier of the server or workstation. Laminated plastic shall be .125 inch thick, white with black center core. Nameplates shall be a minimum of 1x3 inches with minimum .25 inch high engraved block lettering. All nameplates shall be attached to the device in conspicuous location.

B. Workstation Hardware Government Furnished Material (GFM)

1. Computer Workstation Hardware (workstation) shall be a standard unmodified digital desktop computer of modular design or a laptop as described in Section 15951 DIRECT DIGITAL CONTROL

FOR HVAC. The modular components of the workstation or the laptop shall be products of a single manufacturer which advertises national service (service in all 48 contiguous states).

2.04 PRINTERS (GFM)

A. Printer provided shall be local or network printers as shown. Local printers shall have a USB 2.0 interface. Network printers shall have a 100Base-TX interface with an RJ45 connection and shall have a firmware print spooler compatible with the Operating System print spooler.

B. Alarm Printer
1. Laser Printer
a. Laser printers shall meet the following minimum requirements:
1) Resolution: 600 by 600 dots per inch.
2) Printing Time: 6 pages per minute.
3) Data Buffer Size: 10 Megabytes.
4) Media Size: 8.5x11 inches as shown.
5) Paper Cassette: 250 sheet capacity.

2.05 COMPUTER SOFTWARE

A. Operating System (OS) (Latest Version) –(GFM)
1. The operating system (OS) shall support time sychronization via Network Time Protocol (NTP) per RFC 2030, and shall support all installed software. The OS shall be able to obtain screen capture of the monitor display being viewed. The OS shall support all specified software.

B. Office Automation Software (Latest Version) – (GFM)
1. Office Automation Software shall consist of the spreadsheet and word processing portions of the project site's standard office automation software.

C. Virus Protection Software (Latest Version) – (GFM)
1. Virus Protection Software shall consist of the project site's standard virus protection software complete with a virus definition update subscription. Coordinate with Facility's Network specialist on approved software.

D. ANSI/EIA-852 Configuration Server – (GFM)
1. The ANSI/EIA-852 configuration server shall meet the requirements of ANSI/EIA-852.

E. LonWorks Network Configuration Tool
1. The network configuration tool shall meet the following minimum requirements:
a. It shall solely use LonWorks Network Services (LNS) for all network configuration and management for LonWorks devices.
b. It shall be capable of executing LNS plug-ins.
c. It shall be capable of performing network database reconstruction of a LonWorks control network, such that if connected to an existing LonWorks network it has the ability to query the network and create an LNS database for that network and an associated network drawing.
d. It shall allow configuration of the network while off-line such that an operator may set up changes to the network while disconnected from the network, and then execute all of them once connected.
e. It shall have a graphics-based user interface, and be able to display and print a graphical representation of the control network.
f. It shall be capable of generating and printing the following reports:
1) Table containing domain/subnet/nodeID and node identifier for the entire network or any subset thereof, selected by the user.
2) Table containing Standard Network Variable (SNVT) input and output details for any LonWorks device on the network.
3) Table containing Standard Configuration Properties (SCPTs) for any LonWorks device on the network.
g. It shall be capable of merging two existing LNS databases into a single standard LNS database and creating a graphical representation for the combined database.

2.06 Monitoring and Control (M&C) Software

A. The monitoring and control (M&C) software shall be an LNS-compatible client-server software package. The software shall accommodate all points as shown and required and shall be expandable to accommodate up to 50,000 points. The server software shall support clients as specified and shown , with expansion capability to support no less than 50 total clients and no less than 20 clients simultaneously.

B. Passwords.

1. The M&C software shall provide user-based access to M&C functionality. The M&C Software shall obtain user information from the OS or manage M&C user information] and shall recognize at least 100 separate users and have at least 4 levels of user permissions. User permission levels (from most restrictive to most permissive) shall include:
   a. Permission Level 1: View System Graphic Displays.
   b. Permission Level 2: Permission Level 1 plus acknowledge alarms and set up (configure) trends and reports.
   c. Permission Level 3: Permission Level 2 plus override SNVTs and set up (configure) alarms, schedules and demand limiting
   d. Permission Level 4: Permission Level 3 plus create and modify System Graphic Displays and create custom programs.
2. The system shall display the operator's user ID on the monitor while logged in. Passwords shall not be displayed. The system shall maintain a disk file logging all activity of the system. If the file format is not plain ASCII text, the contractor shall provide a means to export or convert the file to plain ASCII text. This file shall maintain, as a minimum, a record of all operators logged onto the system, alarm acknowledgments, commands issued and all database modifications. Passwords shall not be logged. The activity log shall be maintained at the server hardware. The system shall automatically provide a mechanism for archiving the log files for long term record storage.

C. Protocol Drivers

1. The M&C Software may include drivers to other (non-LonWorks) protocols. The protocol driver shall allow the M&C software to read and write values to and from points on the legacy system from all M&C functions. The M&C software shall support reading points from the legacy system and writing these values to SNVTS on the LonWorks network, and reading SNVTs from the LonWorks network and writing these values as points on the legacy network. Use of the driver to integrate additional legacy systems shall not require programming but may require configuration.

D. System Graphic Displays

1. The monitoring and control (M&C) software shall include graphical displays through which an operator, via client or server, can perform real-time access and manipulation of the M&C functions as specified and shown. The graphical displays shall consist of building-level system (air handler units, VAV boxes, chillers, boilers etc) graphic displays, alarm displays, scheduling displays, trending displays, and demand limiting displays. Data associated with an active display shall be updated every 5 seconds.
   a. Navigation Scheme: System graphic displays of building-level systems and points shall be hierarchical displays using a building-to-equipment point-and-click navigation scheme. Each display shall show the building name and number. Each display shall show system wide data such as outside air temperature and humidity in the case of an HVAC system application.
      1) Each building display shall show the building foot print and basic floor plan, and shall clearly show and distinguish between the individual zones and the equipment serving each zone and space. The building display shall also show all space sensor and status readings, as applicable, for the individual zones such as space temperature, humidity, occupancy status, etc. The building display shall show the locations of individual pieces of monitored and controlled equipment.
      2) Each equipment display shall show a one-line diagram control schematic representation of the individual pieces of equipment using the symbols and M&C point data types as specified. Different colors and textures shall be used for various components and real time data. Colors and textures shall be uniform on all displays.
      3) Each display shall clearly distinguish between the following point data types and information:
         (a) Real-time data.

(b) User-entered data.
(c) Overridden or operator-disabled points.
(d) Devices in alarm (unacknowledged).
(e) Out-of-range, bad, or missing data.

b. Navigation Commands: The system graphic displays shall support English language operator commands via point-and-click mouse and keyboard entry for defining and selecting points, parameters, graphics, report generation, and all other functions associated with operation. The operator commands shall be usable from any operator workstation with individual operator passwords as specified.

1) Command Input: Operator's commands shall be full words and acronyms selected to allow operators to use the system without extensive training or any data processing backgrounds. The system shall prompt the operator in full words and acronyms for all required information, identifying acceptable command formats. The operator's response shall be a point-and-click selection, word, phrase, or acronym including parameters where required.

2) Command Input Errors: The system shall supervise operator inputs to ensure they are correct for proper execution. Operator input assistance shall be provided whenever a command cannot be executed because of operator input errors. The system shall explain to the operator why the command cannot be executed. Conditions for which operator error assist messages shall be generated include:
(a) The command used is incorrect or incomplete.
(b) The operator is restricted from using that command.
(c) The command addresses an out-of-range or bad data point.
(d) The command addresses a point that does not exist.
(e) The command would violate constraints.

3) Special Functions: The system shall provide the following point-and-click mouse functions, in addition to all other commands specified:
(a) HELP: shall produce a display of all commands available to the operator. The HELP command, followed by a specific command shall produce context sensitive listing with a short explanation of the purpose, use, and system reaction to that command.
(b) DISPLAY DIAGRAM: shall display diagrams of specific utility systems or other systems as specified.
(c) DIAGRAM DEVELOPMENT: shall allow the user to develop diagrams of specific utility systems or other systems as specified.
(d) PRINT REPORT: Shall allow the operator to initiate printing of reports.

4) Operator's Commands: The operator's commands shall provide the means for entry of control and monitoring commands, and for retrieval of information. Processing of operator commands shall commence within 5 seconds of entry, with some form of acknowledgment provided at that time. The operator's commands shall perform tasks, including:
(a) Request a display of any SNVT or calculated point or any group of related SNVTs and calculated points.
(b) Startup and shutdown selected systems or devices.
(c) Enable and disable individual points.
(d) Override any SNVT point to operator selected value.
(e) Release override to return SNVT point to original value.
(f) Modify time and event scheduling.
(g) Initiate reports.
(h) Generate and format reports.

5) System Graphic Display Hierarchy: The system graphic display shall have a hierarchical structure with at least five levels:
(a) Unit: The unit that a point is associated with, such as an AHU.
(b) Building Sub-Area: A part of a building.
(c) Building: The building that a point is located in or near.
(d) Building Group: A group of buildings.
(e) Facility: Installation included in the UMCS.

c. Symbols Library: The M&C software shall include a library of the symbols listed. Symbols shall at a minimum conform to ASHRAE Handbook where applicable. The software shall allow the operator to create, modify, delete, call-up, list, and store display symbols. A library of callable display symbols shall be furnished, including: Pump, Two- and Three-

way Valves, Flow Sensing Element, Temperature Sensor, Pressure Sensor, Humidity Sensor, Single and Double Deck Air Handling Unit, Fan, Chiller, Boiler, Air Compressor, Piping, Ductwork, Unit Heater, Pressure Reducing Valve, Damper, Electric Meter, Limit Switch, Flow Switch, Temperature Switch, Pressure Switch, Coil, Solenoid Valve, Filter, Condensing Unit, Cooling Tower.

d. Display Editor: The display editor shall enable the user to create, modify, and delete displays and symbols. The primary use shall be for adding and modifying one-line diagrams, status displays, system summaries, and system directories, as new controllers, points, data, and other necessary changes are made. The basic functions shall include:
   1) Create a new graphic.
   2) Group and ungroup graphic symbols.
   3) Modify a portion of a graphic.
   4) Save graphics and symbols as a library object.
   5) Rotate and mirror a graphic.
   6) Delete a graphic.
   7) Place a graphic symbol on a display.
   8) Cancel the display of a graphic.
   9) Assign conditions which automatically initiate the display.
   10) Overlay alphanumerics and graphics.
   11) Save new, modified, or existing graphics as new graphics.
   12) Integrate real-time data with the display.
   13) Define the background color.
   14) Define the foreground color.
   15) Locate the symbols.
   16) Position and edit alphanumeric descriptors.
   17) Establish connecting lines.
   18) Establish sources of latest data and location of readouts.
   19) Display analog values as specified.
   20) Cursor control (up, down, right, left).
   21) Create and display alphanumeric displays.
   22) Assign graphics a depth such that when there are coincident graphics the one with the lower depth is displayed.
   23) Modify graphic properties based on SNVT values.

E. Scheduling

1. The M&C software shall support a minimum of 200 user-definable schedules, and be capable of scheduling any point on the LonWorks network via SNVT and any points available from a connected legacy system via the protocol driver. The specified scheduling functions shall be operator accessible and adjustable via graphics display. The graphics display shall include the following fields and functions:
   a. Current date and time. The O/S and M&C software shall automatically make Daylight Savings Time adjustments. Daylight savings time adjustment shall be capable of being turned off by the operator.
   b. Building name and number.
   c. System identifier and name.
   d. System group. System schedules shall be capable of being grouped by the user to perform according to a common schedule.
   e. Weekly schedules. Each system shall have a weekly schedule based on a seven day per week schedule with independent schedules for each day of the week including no less than 2 'on' times and 2 'off' times per day.
   f. Holiday and special event schedules. System scheduling shall support holiday and special event calendar schedules independent of the daily schedule. Special event schedules shall include one-time events and recurring events. Scheduling of one-time events shall include the beginning and ending dates and times of the event. Holiday and special event schedules shall have precedence over device weekly schedules.

F. Alarms

1. The M&C software shall be capable of handling and managing no less than10,000 alarm points.
   a. Alarm Data. Alarm data to be displayed and stored, as applicable and as specified, shall include:
      1) Identification of alarm including building, system (or sub-system), and device name.
      2) Date and time to the nearest second of occurrence.
      3) Alarm type.

4) Alarm set point (if analog).
5) Engineering units.
6) Current value or status of the alarm point.
7) Alarm priority.
8) Alarm Message: A unique message with a field of 60 characters shall be provided for each alarm. Assignment of messages to an alarm shall be an operator editable function. Secondary messages shall be assignable by the operator for printing to provide further information, such as telephone lists or maintenance functions, and shall be editable by the operator. The system shall provide for 100 secondary messages with a field of 25 lines of 60 characters each.
9) Acknowledgement status of the alarm and, where acknowledged, the time and date of acknowledgement.
10) User who acknowledged the alarm.

b. Alarm Types and Settings: Alarms types shall be high and low fail, and high and low alarms. Alarm settings shall be configurable from the alarm graphic display by the operator for:
1) High fail. Indicates that the source device has failed due to the sensing device or alarm parameter being out-of-range or bad data.
2) High Alarm. Analog alarms shall also include the alarm setpoint value.
3) Low Alarm. Analog alarms shall also include the alarm setpoint value.
4) Low fail. Indicates that the source device has failed due to the sensing device or alarm parameter being out-of-range or bad data.
5) Alarm dead band. For high and low analog alarms, this is the magnitude of the differential, above and below the set point, that causes the alarm to change state.
6) Alarm priority. There shall be two alarm priority levels; critical and informational. Critical alarms shall require acknowledgement by an operator; informational alarms shall not.

c. Alarm Notification and Routing: The M&C software shall be capable of performing alarm notification and routing functions. Upon receipt or generation of an alarm the M&C software shall immediately perform alarm notification and routing according to an assigned routing for that alarm. The M&C software shall support at least 500 alarm routes; an alarm route shall be a unique combination of any of the following destinations:
1) Generate a pop-up up display on designated workstation monitors. The pop-up display shall include identification of the alarm, date and time of the alarm, alarm message, and current value/status of the alarm point. Alarms shall be capable of being acknowledged from the pop-up display.
2) Dial a numeric paging system and leaving a numeric message. The paging system number and numeric message shall be user configurable for each alarm.
3) Send an email message via simple mail transfer protocol(SMTP); RFC 821. The email shall contain a scripted message and all alarm data. The email recipient and scripted message shall be user configurable for each alarm.
4) Print designated alarms to local and networked alarm printers. The printed message shall be the same as the pop-up message.

d. Alarm Display and Acknowledgement. The M&C software shall include an alarm display. A minimum of the most recent 100 system alarms shall be available for display at each workstation as shown, along with all associated alarm data. Alarms shall be capable of being acknowledged from this display. Multiple alarms shall be capable of being acknowledged using a single command. Operator acknowledgment of one alarm shall not automatically be considered as acknowledgment of any other alarm nor shall it inhibit reporting of subsequent alarms.

e. Alarm Storage and Reports:
1) The M&C software shall store each alarm and its associated alarm data to hard disk. The stored data shall be user-sortable and formatted for printing. The M&C software shall be capable of performing real-time trending on a minimum of 5,000 points simultaneously with a minimum trending capacity of 100 points per second. The M&C software shall be capable of displaying and printing a graphical representation of each trend, and of multiple trended points on the same graph. The software shall be capable of saving trend logs to a comma delimited (.CSV) format. Each trend shall be user-configurable for:
(a) Point to trend.

(b) Sampling interval with a minimum sampling interval no greater than 1second, and a maximum sampling interval no less than 1 hour.
(c) Start and Stop Time of Trend: Either Start Time and Stop Time or Start Time and Duration.

G. Programming Language

1. The M&C Software shall incorporate a programming (scripting) language for creating custom applications. Actions that shall be available through the programming language shall include the following functions:
   a. Override SNVTs
   b. Monitor SNVTs
   c. Clock/Timer Functions
   d. PID blocks
   e. Math Functions: Addition, subtraction, multiplication, division, powers, trig and log.
   f. Loops ("for" and "while")
   g. Conditional Branches ("if-then-else")
   h. Variable Define/Assignment/ Use
   i. Provide data to a graphic display
   j. Get data from a graphic display
   k. Initiate alarm conditions
   l. Initiate Reports
   m. Logic Functions: ("and", "or" and "not")
   n. Bitwise logic functions
   o. User defined subroutines and functions

H. Report Generation

1. Software shall be provided with commands to generate and format reports for displaying, printing, and storing on disk and tape. Reports shall be stored by type, date, and time. The destination of each report shall be selectable by the operator. Reports shall use current system values. Database parameters used in reports shall be assignable by the operator. Dynamic operation of the system shall not be interrupted to generate are port. The report generation mode, either automatic or request, shall be operator assignable. The report shall contain the time and date when the sample was taken, and the time and date when the report was generated. Software shall be provided to format and store on a removable diskette all data, trends, profiles, reports and logs specified herein in a comma-delimited text format. Data transfer function shall be accessible by operator command from any workstation, subject to password.
2. The software shall allow for automatic or manual generation of reports. For automatic reports the operator shall be able to specify the time the initial report is to be generated, the time interval between reports, end of period, and the output format for the report. The operator shall be able to modify, or inhibit a periodic report. Manual report generation shall allow for the operator to request at any time the output of any report. The software shall be capable of generating the following standard reports:
   a. Electrical Power usation Report: An electrical power usation summary, operator selectable for substations, meters, or transducers, individual meters and transducers, any group of meters and transducers, and all meters for an operator selected time period. The report shall include the voltage, current, power factor, electrical demand, electrical power consumption, reactive power (Kvar) for each substation, facility, system or equipment as selected by the operator The report shall be automatically printed at the end of each summary period and shall include:
      1) Total period consumption.
      2) Demand interval peak for the period, with time of occurrence.
      3) Power consumption (kWh) over each demand interval.
      4) Average (kW) demand during the 5 to 60 minute user definable interval containing the installation's peak demand.
      5) Time-of-use peak, semi-peak, off-peak, or baseline total kWh consumption.
      6) Reactive power during each demand interval.
      7) Power factor during each demand interval.
      8) Outside air (OA) temperature and relative humidity (RH) taken at the maximum and minimum of OA temperature of the report period with the time and dates of occurrence. At the installation's peak demand interval, the OA temperature and RH shall also be recorded.
      9) Calculated heating and cooling degree days on a 18.3 degrees C (65 degrees F) balance point. Heating and cooling degree day balance point may be operator adjustable.

b. Electrical Peak Demand Prediction Report: A report based on the demand limiting program. The report shall include:
   1) Target.
   2) Actual peak and predicted peak for each demand interval forth at day.
   3) Predicted demand for the next demand interval.

c. Energy Utilization Report: An energy utilization summary, operator selectable, for a, unit, building, area, installation, and the entire UMCS. The report shall include:
   1) Beginning and ending dates and times.
   2) Total energy usage for the current and previous day.
   3) Total energy usage for the current and previous month.
   4) Maximum rate of consumption for the current and previous day.
   5) Maximum rate of consumption for the current and previous month.
   6) Outside air (OA) temperature high, low, and average.
   7) OA relative humidity (RH) or dew point high, low, and average.
   8) Calculated degree days.
   9) OA temperature and RH taken at the maximum and minimum of OA temperature with the time and dates of occurrence. At the installation's peak demand interval, the OA temperature and RH shall also be recorded.

d. Equipment Electrical Consumption Report: An equipment electrical consumption report shall be provided for monitoring the electrical parameters and energy consumption from equipment instrumented or metered. Report shall obtain data for equipment, facility, system, substation metered for power and associated electrical parameters. Report shall be correlated to equipment, systems, facility or substation. Report shall monitor the power consumption (kWh), power factor, reactive power (kvar), current, voltage, and instantaneous demand (kW) of each device and provide high and low level alarm points. Report shall also totalize and report system, facility, substation and equipment energy consumption and other electrical parameters at operator selectable intervals. Report shall provide data for the following intervals as a minimum:
   1) Minutes (operator selectable from 0-60).
   2) Hourly.
   3) Daily.
   4) Weekly.
   5) Monthly.
   6) Yearly.

   Reports shall include the starting and ending time of the reporting interval. Longer reporting intervals shall be accumulated by totalizing the results of shorter intervals.

e. Alarm Report: Outstanding alarms by building or unit, including time of occurrence.

f. Override Report: Points overridden, including time overridden, and identification of operator overriding the point.

g. Run Time Reports: A report totalizing the accumulated run time of individual pieces of equipment. The operator shall be able to select the following subsets of equipment:
   1) Individual equipment items without status feedback.
   2) Individual equipment items with analog or digital status feedback.
   3) Equipment type, such as air handling units.
   4) Specific equipment sizes by types, such as all motors over 15kilowatts (20 hp).
   5) Equipment by physical grouping. The system shall maintain statistics on a number of equipment items equal to the number of digital inputs and outputs. Run time shall be totaled up to 9999 hours. Reports shall be generated on equipment which has reached the target run time specified in the database. The software will provide for manual and automatic reset, operator selectable and settable for each individual run time totalized, reset to zero upon generation of the report, as necessary

2.07 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. The uninterruptible power supply (UPS) shall be a self contained device suitable for installation and operation at the location of Server and Workstation hardware and shall sized to provide a minimum of 30 minutes of operation of the connected hardware. Equipment connected to the UPS shall not be affected in any manner by

a power outage of a duration less than the rated capacity of the UPS. UPS shall be complete with all necessary power supplies, transformers, batteries, and accessories and shall include visual indication of normal power operation, UPS operation, abnormal operation and visual and audible indication of low battery power. The UPS shall be UL 1778approved. UPS powering Server Hardware shall support notification to the server via serial interface of impending battery failure.

2.08 RACKS AND ENCLOSURES

A. Enclosures shall meet NEMA 250 requirements for the installed location. All enclosure penetrations shall be from the bottom of the enclosure, and shall be sealed to preclude entry of water using a silicone rubber sealant.

B. Equipment Racks Equipment racks shall be available in different sizes and shall be either aluminum or steel with bolted or welded construction. Steel equipment racks shall be painted with a flame-retardant paint. Guard rails shall be included each equipment rack and have a copper grounding bar installed and grounded to the earth.

C. FACTORY TEST

1. The Contractor shall perform factory testing of the UMCS as specified. The Contractor is responsible for providing personnel, equipment, instrumentation, and supplies necessary to perform required testing. Written notification of planned testing shall be given to the Government at least 21 days prior to testing, and in no case shall notice be given until after the Contractor has received written Government approval of the specific test procedures. The test procedures shall define the tests required to ensure that the system meets technical, operational, and performance specifications. The test procedures shall define location of tests, milestones for the tests, and identify simulation programs, equipment, personnel, facilities, and supplies required. The test procedures shall provide for testing all capabilities and functions specified and shown. The test procedures shall be developed from the design documentation. The procedures shall cover actual equipment to be used by the Contractor for the specified project and shall consist of detailed instructions for test setup, execution, and evaluation of test results. The Factory Test Report shall document the test procedures and results. Reports shall be delivered to the Government within 7 days after completion of each test.

PART 3 EXECUTION

3.01 PROJECT TIMING

A. TABLE I: PROJECT TIMING specifies the sequencing and timing of submittals as specified in paragraph SUBMITTALS (denoted by an 'S' in the 'TYPE' column) and activities as specified in PART 3: EXECUTION (denoted by an 'E' in the 'TYPE' column).

1. Timing for submittals: The timing specified for submittals is the deadline by which the submittal must be initially submitted to the government. If the submittal is not accepted by the government, the contractor shall revise the submittal and resubmit it to the government within 14 days of notification that the submittal has been rejected. Upon resubmittal there shall be an additional government review period. If the submittal is not accepted the process repeats until the submittal is accepted by the Government.
2. Timing for Activities: The timing specifies for activities indicates the earliest the activity may begin.

TABLE I. PROJECT TIMING

ITEM	TYPE	DESCRIPION	START OF ACTIVITY or DEADLINE FOR SUBMITTAL
1	S	Design Drawings	
2	S	Product Data Sheets	
3	S	Network Bandwidth Calculations	
4	S	Factory Test Report	
5	E	Install UMCS	after approval of 1,2,3,4
6	E	Start-Up and Testing	after 5
7	S	Start-Up and Testing Report	15 days after 6
8	S	Draft As-Built Drawings	15 days after 6

9	S	PVT Phase I Procedures	30 days before scheduled start of 10 and after approval of 7
10	E	PVT Phase I	after approval of 7,8,9
11	S	PVT Phase I Report	15 days after 10
12	S	Preventive Maintenance	after approval of 1,2,3,4Work Plan
13	S	Basic Operator Training Documentation	after approval of 1,2,3,4
14	S	Computer Software	after approval of 1,2,3,4
15	E	Basic Operator Training (PVT Phase II)	after approval of 12,13,14
16	S	PVT Phase II Report	15 days after 15
17	S	Final As-Built Drawings	15 days after 15
18	S	O&M Manual [15] days	after 15
19	S	Advanced Operator Training Documentation	30 days before scheduled start of 20 and after approval of 1,2,3,4
20	E	Advanced Operator Training	30 days after 15 and after approval of 19 and no later than 60 days after 15
21	S	Operator Refresher Training	30 days before 22 and Documentation after approval of 13,19
22	E	Operator Refresher Training	between 90 and 120 days after 15 and after approval of 21

3.02 DRAWINGS AND CALCULATIONS

A. Network Bandwidth Usage Calculations The Contractor shall perform UMCS Network Bandwidth Usage Calculations for heavily loaded UMCS. A heavily loaded UMCS is characterized as one performing the following activities simultaneously:

1. Trending a number of points equal to the specified minimum M&C software trending capacity at 15 minute intervals.
2. Trending (for loop tuning) 20 points at 2 second intervals.
3. Viewing 500 points (via workstations) with a 5 second update interval.
4. Transmitting load shed commands (via SNVTs) to 2,000 controllers in over 1 minute interval.
5. Viewing of 10 system display graphics screens via browsers.

B. UMCS Contractor Design Drawings. Contractor shall revise and update the Contract Drawings to include details of the system design. Details to be shown on the Design Drawing include:

1. Details on logical structure of the network. This includes logic allocation of all network hardware.
2. Manufacturer and model number for each piece of computer and network hardware.
3. Physical location for each piece of network or computer hardware.

C. As-Built Drawings. The Contractor shall prepare draft as-built drawings consisting of points schedule drawings for the entire UMCS and an updated Design Drawing including details of the actual installed system as it is at the conclusion of Start-Up and Testing. In addition to the details shown in the design drawings, the as-built drawing shall include:

1. IP address for each piece of network hardware.
2. IP address for each computer server and workstation.
3. Network identifier (name) for each printer, computer server and computer workstation.
4. LonWorks address for each LON to IP router.

Contractor shall prepare Draft As-Built Drawings upon the completion of Start-Up and Testing and Final As-Built Drawings upon completion of PVT Phase II.

3.03 INSTALLATION REQUIREMENTS

A. Installation. The Contractor shall install system components as shown and specified and in accordance with the manufacturer's instructions and shall provide necessary interconnections, services, and adjustments required for a complete and operable system. Communication equipment and cable grounding shall be installed as necessary to preclude ground loops, noise, and surges from adversely affecting system operation. Wiring in exposed areas, including low voltage wiring, shall be installed in metallic raceways o EMT.

1. Isolation, Penetrations of Buildings and Clearance from Equipment The UMCS shall be completely installed and ready for operation, as specified and shown. Dielectric isolation shall be provided where dissimilar metals are used for connection and support. Penetrations through and mounting holes in the building exteriors shall be made watertight. Holes in concrete, brick, steel and wood walls shall be drilled or core drilled with proper equipment; conduits installed through openings shall be sealed with materials which are compatible with existing materials. Openings shall be sealed with materials which meet the requirements of NFPA 70.

3.04 INSTALLATION OF EQUIPMENT

A. Wire and Cable Installation System components and appurtenances shall be installed in accordance with NFPA 70, manufacturer's instructions and as shown. Necessary interconnections, services, and adjustments required for a complete and operable signal distribution system shall be provided. Components shall be labeled in accordance with ANSI/TIA/EIA-606. Penetrations in fire-rated construction shall be firestopped. Conduits, outlets and raceways shall be installed in accordance Code. Wiring shall be installed in accordance with ANSI/TIA/EIA-568-A. Wiring, and terminal blocks and outlets shall be marked in accordance with ANSI/TIA/EIA-606. Non fiber-optic cables shall not be installed in the same cable tray, utility pole compartment, or floor trench compartment with ac power cables. Cables not installed in conduit or raceways shall be properly secured and neat in appearance.

B. Grounding Signal distribution system ground shall be installed in the telecommunications entrance facility and in each telecommunications closet in accordance with ANSI/TIA/EIA-607 and Section 16415A ELECTRICAL WORK,INTERIOR. Equipment racks shall be connected to the electrical safety ground.

C. Computer Hardware and Software

1. Hardware Installation Computer Hardware shall be installed as shown. Computer Servers shall be powered through a UPS, and shall be installed and configured such that the server will automatically undergo a clean shutdown upon low battery signal from the UPS.
2. Software Installation Contractor shall install software as follows:
   a. Operating system: The contractor shall install the OS on each Server and Workstation and configure user names and passwords.
   b. Office Automation Software: The contractor shall install the office automation software on each server and workstation.
   c. Virus Protection software: The contractor shall install the virus protection software on each server and workstation and shall configure weekly virus scans. Coordinate with Facility's Network specialist on approved software.
   d. ANSI/EIA-852 Configuration Server: The contractor shall install and configure the ANSI/EIA-852 Configuration Server. The ANSI/EIA-852 Configuration Server may be installed on Server Hardware, Workstation Hardware, or an ANSI-709.3 to IP Router.
   e. Network Configuration Tool: The contractor shall install the network configuration tool software as shown. The server version of the software shall be installed on server hardware, and client versions shall be installed on client or server hardware.
   f. Monitoring and Control Software: The contractor shall install the monitoring and control software as shown. The server version of the software shall be installed on server hardware, and client versions shall be installed on client or server hardware.
3. Network Hardware The contractor shall install all network hardware in an enclosure or a telecommunication closet as defined by the project site. IP Network Hardware shall be powered through a UPS.3.4.5 IP Addresses For equipment requiring IP addresses, the contractor shall coordinate with the DOIM to obtain IP addresses]
4. IP Network Installation. Government will provide IP network functioning at least 100 Mbps. Contractor installed UMCS network bandwidth requirements calculated as specified in Paragraph DRAWINGS AND CALCULATIONS shall not exceed 10 Mbps.

3.05 INTEGRATION OF BUILDING LEVEL CONTROLS

A. 3.5.1 Integration of LonWorks (per Section 15951) Systems. The contractor shall perform the following tasks to integrate the building system into the UMCS:

1. If the building control network contains an IP backbone, install and configure an IP router to connect the building IP network to the UMCS IP Network. Re-configure ANSI-709.3 to IP Routers in the building to use the UMCS ANSI/EIA-852 Configuration Server. Otherwise, install and configure an ANSI-709.3 to IP Router to connect the building levelTP/FT-10 network to the UMCS IP Network
2. Update the UMCS LNS Database and update UMCS Network representation(drawings) in the Network Configuration Tool. The LNS database shall be updated by merging the building database with the UMCS database. Incases where the building database is not available the Contractor shall use the Network Configuration Tool software to discover the building network and create an LNS Database for the building and then merge the building database and the UMCS database.
3. Establish network variable bindings for all alarms as shown.
4. Establish network variable bindings for UMCS demand limit and operator overrides via occupancy SNVTS.
5. Configure M&C functionality
   a. Create graphical pages for System Graphic Displays as shown and specified. SNVTs for monitoring shall be polled from the M&C Software via the LNS Server, and shall be updated while the monitoring graphic for that SNVT is active.
   b. Configure alarm handling for required alarm SNVTs as shown on the Points Schedule and Alarm Routing Schedules and as specified.
   c. Configure the scheduling function of the M&C software to schedule systems (SNVTs) as shown on the Points Schedule and as specified. SNVTs used for scheduling shall be bound with a maximum send time (minimum time between subsequent transmissions of the SNVT) of 45 minutes. Label schedules and schedules points with full English-language descriptors.
   d. Create trends for required SNVTs as shown on the Points Schedule and as specified. Trends SNVTs at 15 minute intervals. SNVTs used for trends shall be polled by the M&C Software.
   e. Configure Demand Limiting as shown on the Demand Limit Schedule and Points Schedule and as specified.
6. Integration of Legacy (not per Section 15951) LonWorks Systems. The Contractor shall perform all tasks required to integrate a LonWorks System installed per Section 15951, and shall complete Point Schedules for the building level network.
7. Integration of Legacy non-LonWorks Systems at Building via Gateway. When integrating a non-LonWorks Legacy system using a LonWorks Gateway the Contractor shall perform the following tasks:
   a. Install and configure the LonWorks Gateway, including adding the gateway to the LNS database and network drawing. The gateway shall be configured such that the required data (points) as shown from the Legacy system are available as SNVTs on the LonWorks side of the gateway and that required commands as shown on the legacy side of the gateway can be written as SNVTs on the LonWorks side of the gateway.
   b. When the Gateway performs protocol translation to ANSI/EIA-709.1B,a LON to IP Router shall be installed on configured to connect the gateway to the UMCS IP Network.
   c. Establish network variable bindings for all alarms as shown.
   d. Configure M&C functionality as specified in paragraph Integration of LonWorks (per Section 15951) Systems.
8. Integration of Legacy non-LonWorks Systems at M&C Server via Protocol Driver When integrating non-LonWorks legacy systems at the M&C Server the Contractor shall :
   a. Extend the legacy system to the M&C Server
   b. Configure the M&C software protocol driver to provide access to required legacy system data as shown.
   c. Configure M&C functionality as specified in paragraph Integration of LonWorks (per Section 15951) Systems

3.06 START-UP AND TESTING

A. Contractor shall test all equipment and perform all other tests necessary to ensure the system is installed and functioning as specified. Contractor shall prepare a Start-Up and Testing Report documenting all tests

performed and their results and certifying that the system meets the requirements specified in the contract documents.

3.07 PERFORMANCE VERIFICATION TEST (PVT)

A. PVT Phase I Procedures. PVT Procedures shall include:
1. Network bandwidth usage and available bandwidth(throughput)measurements. Network bandwidth usage shall reference the heavy usage numbers in paragraph Bandwidth Usage Calculation.
2. Test System Reaction during PVT: Under system normal heavy load{as defined in paragraph Bandwidth Usage Calculation), no more than 10seconds shall lapse from the time an alarm is generated at a node until the M&C software provides notification and the alarm is displayed. The total system response time from initiation of a control action command from the workstation, to display of the resulting status change on the workstation shall not exceed 20 seconds under system normal heavy load conditions assuming a zero response time for operation of the node's control device.
3. Verification of IP Connectivity.
4. Verification of configuration of M&C Software functionality.

B. PVT Phase I. The Contractor shall demonstrate compliance of the control system with the contract documents. Using test plans and procedures previously approved by the Government, the Contractor shall demonstrate all physical and functional requirements of the project. Upon completion of PVT Phase I and as specified the Contractor shall prepare and submit the PVT Phase I Report documenting all tests performed during the PVT and their results. The PVT report shall include all tests in the PVT Procedures and any other testing performed during the PVT. Failures and repairs shall be documented with test results.

C. PVT Phase II. PVT Phase II shall consist of Basic Operator Training. Failures or deficiencies of the UMCS during Basic Operator Training shall be considered PVT failures. Upon completion of PVT Phase II and as specified the Contractor shall prepare and submit the PVT Phase II Report documenting any failures which occurred and repairs performed during PVT Phase II

3.08 TRAINING

The Contractor shall conduct training courses for designated personnel in the maintenance, service, and operation of the system as specified, including specified hardware and software. The training shall be oriented to the specific system provided under this contract. The Contractor is responsible for furnishing audiovisual equipment and other training material and supplies (Refer to Section 15951 DIRECT DIGITAL CONTROL FOR HVAC). When training is conducted at Government facilities, the Government reserves the right to videotape the training sessions forater use. A training day is defined as 8 hours of classroom instruction, excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility. For guidance in planning the required instruction, the Contractor should assume that attendees will be tradesmen such as electricians or boiler operators. Approval of the Contractor' straining schedule shall be obtained from the Government at least 30 days prior to the first day of training.

A. Training Documentation. The Contractor shall prepare training documentation for each course. Basic Operator Training Documentation, Advanced Operator Training Documentation, and Operator Refresher Training Documentation shall each consist of:
1. Course attendance list: A list of course attendees shall be developed in coordination with and signed by the Controls shop supervisor.
2. Training Manuals: Training manuals shall include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson. Where the Contractor presents portions of the course material by audiovisuals, copies of those audiovisuals shall be delivered to the Government as a part of the printed training manuals.

B. Basic Operator Training The Basic Operator Training course shall be taught at the project site on he installed system for a period of no less than 5 training days during Phase 2 of the PVT. A maximum of ten personnel will attend this course. This training shall be targeted towards training personnel in he day-to-day operation and basic maintenance of the system. Upon completion of this course, each student, using appropriate documentation, should be able to start the system, operate the system, recover the system after a failure, perform routine maintenance and describe the specific hardware architecture and operation of the system. This course shall at a minimum include:
1. General system architecture.
2. Functional operation of the system, including workstations.

3. System start-up procedures.
4. Failure recovery procedures.
5. Schedule configuration.
6. Trend configuration.
7. Reports generation.
8. Alarm reporting.
9. Diagnostics.
10. Historical files.
11. Maintenance procedures:
    a. Physical layout of each piece of hardware.
    b. Troubleshooting and diagnostic procedures.
    c. Preventive maintenance procedures and schedules.

END OF SECTION

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TESTING, ADJUSTING AND BALANCING

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. Procure the services of an independent air balance and testing agency (Testing Agency), which specializes in the balancing and testing of heating, ventilating, and air conditioning systems, to balance, adjust, and test air moving equipment and air distribution systems including verification of HVAC performance.

B. This Section contains reference to Work that shall be carried out by the Contractor, other than that required to be completed by the Testing Agency.

C. Related Work Specified Elsewhere:
1. Scope of Work

1.02 QUALITY ASSURANCE

A. Testing Agency:
1. Qualifications. The independent air balance agency shall provide proof of having successfully completed at least five projects of similar size and scope and shall be currently certified by the "Associated Air Balance Council" (AABC)), or the "National Environmental Balancing Bureau" (NEBB).
2. All Work by this agency shall be done under direct supervision of an NEBB or AABC certified supervisor ***employed by them. All instruments used by this agency shall be accurately calibrated and maintained in good working order. If requested, the tests shall be conducted in the presence of the Resident Engineer or their representative.

B. Reference Standards:
1. Comply with applicable procedures and standard of "National Environmental Balancing Bureau" or the "Associated Air Balance Council".

1.03 SUBMITTALS

A. First:
1. Submit 3 copies of documentation to confirm compliance with quality assurance provisions:
a. Organization, supervisor and personnel training, and qualifications.
b. Specimen copy of each of the report forms proposed for use.

B. Second: At least 60 days prior to starting field Work, submit 3 copies of:
1. A set of report forms filled out as to the design flow values and the installed equipment pressure drops, and the required cfm for air terminals.
2. A complete list of instruments proposed to be used, organized in appropriate categories, with data sheets for each. Show:
a. Manufacturer and model number.
b. Description and use when needed to further identify the instrument.
c. Size or capacity range.
d. Latest calibration date.
3. The Resident Engineer will review submittals for compliance with Contract documents, and will return one set marked to indicate:
a. Discrepancies noted between data shown and Contract documents.
b. Additional, or more accurate, instruments required.
c. Requests for re-calibration of specific instruments.
4. Third: The Testing Agency shall perform the tests hereinafter described, compile the test data, and submit 7 copies of the complete test data to the Contractor for forwarding to the Resident Engineer, for review. Test data shall include all items listed below as "Record" and "Verify".

1.04 JOB CONDITIONS

A. The Testing Agency shall review the project design and/or ductwork shop drawings, and advise the Contractor to provide and install (at no additional cost to the Owner) additional, or relocate balancing devices, deemed necessary by the Testing Agency to enable correct balancing to be completed.

B. Prior to start of testing, adjusting and balancing, verify that required "Job Conditions" are met:
1. Systems installation is complete and in full operation.
2. Outside conditions are within a reasonable range relative to design conditions.
3. Lights are turned "on" when lighting is included in the cooling load.
4. Special equipment such as computers, laboratory equipment, and electronic equipment are in full operation.

C. Coordination:
1. Coordinate services with the Work of the various trades to ensure rapid completion of the services.
2. Promptly report to Contractor and the Resident Engineer any deficiencies noted during performance of services to allow immediate corrective action.
3. If any of the systems are incomplete or deficiencies are noted, stop testing and balancing of the system, notify the Resident Engineer and Contractor, and restart only when corrective action has been taken by the Contractor.

1.05 GUARANTEE

A. Testing Agency shall include an extended warranty of 90 days, after completion of test and balance Work, during which time the Resident Engineer at his discretion may request a recheck, or resetting of any outlet, supply air fan, return/exhaust fan or pump as listed in test report. The Testing Agency shall provide technicians to assist the Resident Engineer in making any tests he may require during this period of time.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 INSTALLATION/APPLICATION/PERFORMANCE/ERECTION

A. Testing Procedure for Air Systems.
1. The Testing Agency shall perform leakage tests on all ductwork of 4 inch Wg class and higher. Testing shall be in accordance with NEBB/AABC Procedures. No audible or visual leak shall be acceptable. Tested sections shall be marked and identified by the Testing Agency.
2. The Testing Agency shall perform the following tests, and balance system in accordance with the following requirements.
   a. Check and adjust fan rpm to design requirements and record fan motor amperes.
   b. Test and record fan motor amperes at design rpm.
   c. Make pitot tube traverse of main supply ducts and adjust fan rpm to obtain design cfm (cubic meters per second.)
   d. Test, adjust and record system static pressures, suction and discharge ducts.
   e. Test and adjust system for design recirculated air, cfm (cubic meters per second.)
   f. Test and adjust system for design cfm (cubic meters per second) outside air (minimum and maximum.)
   g. Test and record entering air temperatures. (D.B. Heating and Cooling.)
   h. Test and record entering air temperatures. (W.B. Cooling.)
   i. Test and record leaving air temperatures. (D.B. Heating and Cooling.)
   j. Test and record leaving air temperatures. (W.B. Cooling.)
   k. Adjust all main supply and return air ducts to proper design cfm (cubic meters per second.)
   l. Adjust all zones to proper design cfm (cubic meters per second), supply and return.
   m. Test and adjust each diffuser, and register to within ten percent of design requirements.
   n. Each diffuser, and register shall be identified as to location and area.
   o. Size, type, and manufacturer of diffusers, registers, and all tested equipment shall be identified and listed. Manufacturer's ratings on all equipment shall be used to make required calculations.

p. Readings and tests of diffusers and registers shall include required fpm (meters per second) velocity and test resultant velocity, required cfm (cubic meters per second) and test resultant cfm (cubic meters per second) after adjustments.

q. In cooperation with the temperature control manufacturer's representative, the setting adjustments of automatically operated dampers shall be set to operate as specified, indicated, and/or noted. The air balance and testing agency shall check all controls for proper calibrations and list all controls requiring adjustment by control installers.

r. All diffusers and registers shall be adjusted to minimize drafts in all areas.All fans that are connected to headers only for future use shall be set to deliver the design cfm (cubic meters per second) at the design conditions shown in the schedule.

s. System static set point (to satisfy system requirements) shall be recorded.

t. Static pressure loss, at design air flow shall be measured and recorded across each component, in each system (i.e. filters, dampers, coils, etc).

u. All fans shall be tested and adjusted to meet the design requirements and final ampere readings shall be taken.

v. As a part of the Work of this Contract, the Contractor shall make any adjustments to the pulleys, belts, and dampers (or the addition of dampers required for correct balance) as recommended by the Testing Agency, at no additional cost to Owner.

w. Lock all balancing dampers after final setting, and mark location.

END OF SECTION

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DIRECT DIGITAL CONTROL FOR HVAC

PART 1 GENERAL

1.01 SYSTEM REQUIREMENTS

A. Systems installed under this guide specification shall have the following characteristics:.
The control system shall be an open implementation of LonWorks technology using ANSI/EIA-709.1B as the communications protocol and using LonMark Standard Network Variable Types (SNVTs) as defined in LonMark SNVT Master List for communication over the network.
LonWorks Network Services (LNS) shall be used for all network management including addressing and binding. A copy of the LNS database shall be submitted to the project site as specified.
The hardware shall perform the control sequences as specified and shown to provide control of the equipment as specified and shown.
Control sequence logic shall reside in DDC hardware in the building. The building control network shall not be dependent upon connection to a Utility Monitoring and Control System (UMCS) for performance of control sequences in this specification. The hardware shall, to the greatest extent practical, perform the sequences without reliance on the building network.
The hardware shall be installed such that individual control equipment can be replaced by similar control equipment from other equipment manufacturers with no loss of system functionality.
All necessary documentation, configuration information, configuration tools, programs, drivers, and other software shall be licensed to and otherwise remain with the government such that the government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the contractor.
The contractor shall provide sufficient documentation and data, including rights to documentation and data, such that the government or their agents can execute work to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the contractor.
Hardware shall be installed and configured such that the government or their agents are able to perform repair, replacement, and upgrades of individual hardware without further interaction with the contractor.
Control hardware shall be installed and configured to provide all input and output Standard Network Variables (SNVTs) as shown.
All DDC devices installed under this specification shall communicate via ANSI/EIA-709.1B. The control system shall be installed such that a SNVT output from any node on the network can be bound to any other node in the domain.

B. Nameplates, Lens Caps, and Tags: Nameplates and lens caps bearing legends as shown and tags bearing device-unique identifiers as shown shall have engraved or stamped characters. A plastic or metal tag shall be mechanically attached directly to each device or attached by a metal chain or wire. Each airflow measurement station shall have a tag showing flow rate range for signal output range, duct size, and identifier as shown.

C. Verification of Dimensions: After becoming familiar with all details of the work, the Contractor shall verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work.

D. Drawings: Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, shall arrange such work accordingly, and shall furnish all work necessary to meet such conditions.

E. Power-Line Surge Protection: Equipment connected to ac circuits shall be protected from power-line surges. Equipment protection shall meet the requirements of IEEE C62.41. Fuses shall not be used for surge protection.

F. Surge Protection for Transmitter and Control Wiring: DDC system control-panel equipment shall be protected against surges induced on control and transmitter wiring installed outside and as shown. The equipment protection shall be tested in the normal mode and in the common mode, using the following two waveforms:
A 10-microsecond by 1,000-microsecond waveform with a peak voltage of 1,500 volts and a peak current of 60 amperes.
An eight microsecond by 20-microsecond waveform with a peak voltage of 1,000 volts and a peak current of 500 amperes.

G. System Overall Reliability Requirement: The system shall be configured and installed to yield a mean time between failure (MTBF) of at least 40,000 hours. Each DDC controller shall be designed, configured, installed and programmed to provide for stand alone operation with minimal performance degradation on failure of other system components to which it is connected or with which it communicates.

H. DDC System Network Accessibility: Where the systems to be controlled by the DDC system are located in multiple mechanical rooms, each mechanical room shall have at least one communication port for the portable workstation/tester. DDC controllers shall be located in the same room as the equipment being controlled or in an adjacent space which has direct access to the equipment room.

I. System Accuracy and Display: The system shall maintain an end-to-end accuracy for one year from sensor to operator's console display for the applications specified and shall display the value as specified. Each temperature shall be displayed and printed to nearest 1 degree F.
Space Temperature: Space temperature with a range of 50 to 86 degrees F plus or minus 1 degree F for conditioned space; 30 degrees F to 120 degrees F plus or minus 1 degree F for unconditioned space.
Duct Temperature: Duct temperature with a range of 40 to 140 degrees F plus or minus 1 degree F.
Outside Air Temperature: Outside air (OA) temperature with a range of minus -40 to plus 130 degrees F plus or minus 1 degree F.
Water Temperature: Water temperature with a range of minus 1 to plus 40 degrees C plus or minus 0.5 degree C; the range of 40 to 120 degrees C plus or minus 1 degree C; and water temperatures for the purpose of performing energy calculations using differential temperatures to plus or minus 0.5 degree C using matched sensors.
High Temperature: High temperature with a range of 100 to 260 degrees C plus or minus 1 degree C.
Relative Humidity: Relative humidity, within a range of 20 to 80 percent, plus or minus 6.0 percent of range (display and print to nearest 1.0 percent).
Pressure: Pressure with a range for the specific application plus or minus 2.0 percent of range.
Flow: Flow with a range for the specific application plus or minus 3.0 percent of range, and flows for the purpose of thermal calculations to plus or minus 2.0 percent of actual flow (display and print to nearest unit, such as L/second.
KWh and kW Demand: KWh and kW demand with a range for the specific application plus or minus 1.0 percent of reading (display and print to nearest kWh or kW).
Analog Value Input: An analog value input to the system's equipment via an AI with a maximum error of 0.50 percent of range, not including the sensor or transmitter error. This accuracy shall be maintained over the specified environmental conditions.

1.02 SUBMITTALS

A. Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.

SD-02 Shop Drawings

HVAC Control System; G

Drawings shall be on 24” x 36” sheets in the form and arrangement shown. The drawings shall use the same abbreviations, symbols, nomenclature and identifiers shown. Each control system element on a drawing shall have a unique identifier as shown. The HVAC Control System Drawings shall be delivered together as a complete submittal. Deviations must be approved by the Contracting Officer. Drawings shall be submitted along with Submittal SD-03 Product Data.

HVAC Control System Drawings shall include the following:

Sheet One: Drawing Index, HVAC Control System Legend.
Sheet Two: Valve Schedule, Damper Schedule.
Sheet Four: Control System Schematic and Equipment Schedule.
Sheet Five: Sequence of Operation and Data Terminal Strip Layout.
Sheet Six: Control Loop Wiring Diagrams.
Sheet Seven: Motor Starter and Relay Wiring Diagram.
Sheet Eight: Communication Network and Block Diagram.
Sheet Nine: DDC Panel Installation and Block Diagram.
(Repeat Sheets Four through Seven for each AHU System.)

The HVAC Control System Drawing Index shall show the name and number of the building, site, State or other similar designation, and Country. The Drawing Index shall list HVAC Control System Drawings, including the drawing number, sheet number, drawing title, and computer filename when used. The HVAC Control System Legend shall show generic symbols and the name of devices shown on the HVAC Control System Drawings.

The valve schedule shall include each valve's unique identifier, size, flow coefficient Kv, pressure drop at specified flow rate, spring range, positive positioner range, actuator size, close-off pressure data, dimensions, and access and clearance requirements data. Valve schedules may be submitted in advance but shall be included in the complete submittal.

The damper schedule shall contain each damper's and each actuator's identifier, nominal and actual sizes, orientation of axis and frame, direction of blade rotation, spring ranges, operation rate, positive positioner ranges, locations of actuators and damper end switches, arrangement of sections in multi-section dampers, and methods of connecting dampers, actuators, and linkages. The Damper Schedule shall include the maximum leakage rate at the operating static-pressure differential. The Damper Schedule shall contain actuator selection data supported by calculations of the torque required to move and seal the dampers, access and clearance requirements. Damper schedules may be submitted in advance but shall be included in the complete submittal.

The HVAC control system schematics shall be in the form shown, and shall show all control and mechanical devices associated with the HVAC system. A system schematic drawing shall be submitted for each HVAC system.

The HVAC control system equipment Schedule shall be in the form shown. All devices shown on the drawings having unique identifiers shall be referenced in the equipment schedule. Information to be included in the equipment schedule shall be the control loop, device unique identifier, device function, setpoint, input range, and additional important parameters (i.e., output range). An equipment schedule shall be submitted for each HVAC system.

The HVAC control system sequence of operation shall reflect the language and format of this specification, and shall refer to the devices by their unique identifiers as shown. No operational deviations from specified sequences will be permitted without prior written approval of the Contracting Officer. Sequences of operation shall be submitted for each HVAC control system including each type of terminal unit control system.

The HVAC control system wiring diagrams shall be functional wiring diagrams which show the interconnection of conductors and cables to HVAC control panel terminal blocks and to the identified terminals of devices, starters and package equipment. The wiring diagrams shall show necessary jumpers and ground connections. The wiring diagrams shall show the labels of all conductors. Sources of power required for HVAC control systems and for packaged equipment control systems shall be identified back to the panel board circuit breaker number, HVAC system control panel, magnetic starter, or packaged equipment control circuit. Each power supply and transformer not integral to a controller, starter, or packaged equipment shall be shown. The connected volt-ampere load and the power supply volt-ampere rating shall be shown. Wiring diagrams shall be submitted for each HVAC control system.

SD-03 Product Data

Manufacturer's Catalog Data; G

Product specific catalog cuts shall be in booklet form, indexed to unique identifiers, and shall consist of data sheets that document compliance with the specification. Where multiple components are shown on a catalog cut, the application specific component shall be marked. Markings which are not reproduced when photo-copied shall not be used.

Programming Software; G

Programming software for each General Purpose Programmable Controller (GPPC) shall be submitted as a Technical Data Package and shall be licensd to the project site. Software shall be submitted on CD-ROM and 3 hard copies of the software user manual shall be submitted for each piece of software provided.

GPPC Application Programs; G

The installed GPPC Application Programs shall be submitted on CD-ROM as a Technical Data Package. The CD-ROM shall include a list or table of contents clearly indicating which application program is associated with each device. 2 copies of the GPPC Application Programs CD-ROM shall be submitted.

XIF files; G

External interface files (XIF files) shall be submitted as a technical data package for each model of DDC Hardware furnished under this specification. XIF files shall be submitted on CD-ROM.

LNS Database

Two copies of the LNS Database for the complete control network shall be submitted as a Technical Data Package. Each copy shall be on CD-ROM and shall be clearly marked identifying it as the LNS Database for the work covered under this specification and with the date of the most recent database modification.

LNS Plug-in

LNS Plug-ins for each Application Specific Controller shall be submitted as a Technical Data Package. LNS Plug-ins distributed under a license shall be licensed to the project site. Plug-ins shall be submitted on CD-ROM and hard copy manuals, if available, shall be submitted for each plug-in provided.

Service Organizations

Six copies of a list of service organizations qualified to service the HVAC control system. The list shall include the service organization name, address, technical point of contact and telephone number, and contractual point of contact and telephone number.

Equipment Compliance Booklet

The HVAC Control System Equipment Compliance Booklet (ECB) shall be in booklet form and indexed, with numbered tabs separating the information on each device. It shall consist of, but not be limited to, data sheets and catalog cuts which document compliance of all devices and components with the specifications. The ECB shall be indexed in alphabetical order by the unique identifiers. Devices and components which do not have unique identifiers shall follow the devices and components with unique identifiers and shall be indexed in alphabetical order according to their functional name. The ECB shall include a Bill of Materials for each HVAC Control System. The Bill of Materials shall function as the Table of Contents for the ECB and shall include the device's unique identifier, device function, manufacturer, model/part/catalog number used for ordering, and tab number where the device information is located in the ECB. The ECB shall be submitted along with Submittal SD-02 Shop Drawings.

Commissioning Procedures

Six copies of the HVAC control system commissioning procedures, in booklet form and indexed, 60 days prior to the scheduled start of commissioning. Commissioning procedures shall be provided for each HVAC control system, and for each type of terminal unit control system. The Commissioning procedures shall reflect the format and language of this specification, and refer to devices by their unique identifiers as shown. The Commissioning procedures shall be specific for each HVAC system, and shall give detailed step-by-step procedures for commissioning of the system.

The Commissioning procedures shall include detailed, product specific set-up procedures, configuration procedures, adjustment procedures, and calibration procedures for each device. Where the detailed product specific commissioning procedures are included in manufacturer supplied manuals, reference may be made in the HVAC control system commissioning procedures to the manuals.

An HVAC control system commissioning procedures equipment list shall be included that lists the equipment to be used to accomplish commissioning. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

Performance Verification Test Procedures

Six copies of the HVAC Control System Performance Verification Test Procedures, in booklet form and indexed, 60 days before the Contractor's scheduled test dates. The performance verification test procedures shall refer to the devices by their unique identifiers as shown, shall explain, step-by-step, the actions and expected results that will demonstrate that the HVAC control system performs in accordance with the sequences of operation, and other contract documents. An HVAC control system performance verification test equipment list shall be included that lists the equipment to be used during performance verification testing. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

Training; G

An outline for the HVAC control system training course with a proposed time schedule. Approval of the planned training schedule shall be obtained from the Government at least 60 days prior to the start of the training. Six copies of HVAC control system training course material 30 days prior to the scheduled start of the training course. The training course material shall include the operation manual, maintenance and repair manual, and paper copies of overheads used in the course.

SD-05 Design Data

Network Bandwidth Usage Calculations; G

Network Bandwidth Usage Calculations may be submitted as a Technical Data Package.

SD-06 Test Reports

Start-Up and Testing Report; G

The Start-Up and Testing Report may be submitted as a Technical Data Package.

PVT Procedures; G

PVT Procedures may be submitted as a Technical Data Package.

PVT Report: G

The PVT Report may be submitted as a Technical Data Package.

Commissioning Report

Six copies of the HVAC Control System Commissioning Report, in booklet form and indexed, within 30 days after completion of the system commissioning. The commissioning report shall include data collected during the HVAC control system commissioning procedures and shall follow the format of

the commissioning procedures. The commissioning report shall include all configuration checksheets with final values listed for all parameters, setpoints, P, I, D setting constants, calibration data for all devices, results of adjustments, and results of testing.

Performance Verification Test; G

Six copies of the HVAC Control System Performance Verification Test Report, in booklet form and indexed, within 30 days after completion of the test. The HVAC control system performance verification test report shall include data collected during the HVAC control system performance verification test. The original copies of all data gathered during the performance verification test shall be turned over to the Government after Government approval of the test results.

SD-10 Operation and Maintenance Data

Operation Manual

Maintenance and Repair Manual

Six] copies of the HVAC Control System Operation Manual for each HVAC control system, 30 days before the date scheduled for the training course.

1.03 DELIVERY AND STORAGE

A. Products shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, and other contaminants, within the storage condition limits published by the equipment manufacturer. Dampers shall be stored so that seal integrity, blade alignment and frame alignment are maintained.

1.04 OPERATION MANUAL

A. An HVAC control system operation manual in indexed booklet form shall be provided for each HVAC control system. The operation manual shall include the HVAC control system sequence of operation, and procedures for the HVAC system start-up, operation and shut-down. The operation manual shall include as-built HVAC control system detail drawings. The operation manual shall include the as-built configuration checksheets, the procedures for changing HVAC control system setpoints, and the procedures for placing HVAC system controllers in the manual control mode.

The procedures for changing HVAC control system setpoints shall describe the step-by-step procedures required to change the process variable setpoints, the alarm setpoints, the bias settings, and setpoint reset schedules.

The procedures for placing HVAC system controllers in the manual control mode shall describe step-by-step procedures required to obtain manual control of each controlled device and to manually adjust their positions.

1.05 MAINTENANCE AND REPAIR MANUAL

A. An HVAC control system maintenance and repair manual in indexed booklet form in hardback binders shall be provided for each HVAC control system. The maintenance and repair manual shall include the routine maintenance checklist, a recommended repair methods list, a list of recommended maintenance and repair tools, the qualified service organization list, the as-built commissioning procedures and report, the as-built performance verification test procedures and report, and the as-built equipment data booklet.

The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all devices listed in the equipment compliance booklet, the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference.

The recommended repair methods list shall be arranged in a columnar format and shall list all devices in the equipment data compliance booklet and state the guidance on recommended repair methods, either field repair, factory repair, or whole-item replacement.

The as-built equipment data booklet shall include the equipment compliance booklet and manufacturer supplied user manuals and information.

If the operation manual and the maintenance and repair manual are provided in a common volume, they shall be clearly differentiated and separately indexed.

1.06 MAINTENANCE AND SERVICE

A. Services, materials and equipment shall be provided as necessary to maintain the entire system in an operational state as specified for a period of one year after successful completion and acceptance of the performance Verification Test. Impacts on facility operations shall be minimized.

B. Description of Work: The adjustment and repair of the system shall include the manufacturer's required adjustments of computer equipment, software updates, transmission equipment and instrumentation and control devices.

C. Personnel: Service personnel shall be qualified to accomplish work promptly and satisfactorily. The Government shall be advised in writing of the name of the designated service representative, and of any changes in personnel. The Contractor shall submit a list of Service Organizations as specified in the Submittals paragraph.

D. Scheduled Inspections: Two inspections shall be performed at six-month intervals and all work required shall be performed. Inspections shall be scheduled in June and December. These inspections shall include:
Visual checks and operational tests of equipment.
Fan checks and filter changes for control system equipment.
Clean control system equipment including interior and exterior surfaces.
Check and calibrate each field device. Check and calibrate 50 percent of the total analog points during the first inspection. Check and calibrate the remaining 50 percent of the analog points during the second major inspection. Certify analog test instrumentation accuracy to be twice that of the device being calibrated. Randomly check at least 25 percent of all digital points for proper operation during the first inspection. Randomly check at least 25 percent of the remaining digital points during the second inspection.
Run system software diagnostics and correct diagnosed problems.
Resolve any previous outstanding problems.

E. Scheduled Work: This work shall be performed during regular working hours, Monday through Friday, excluding legal holidays.

F. Emergency Service: The Government will initiate service calls when the system is not functioning properly. Qualified personnel shall be available to provide service to the system. A telephone number where the service supervisor can be reached at all times shall be provided. Service personnel shall be at the site within 24 hours after receiving a request for service. The control system shall be restored to proper operating condition within three calendar days after receiving a request for service.

G. Operation: Scheduled adjustments and repairs shall include verification of the control system operation as demonstrated by the applicable tests of the performance verification test.

H. Records and Logs: Dated records and logs shall be kept of each task, with cumulative records for each major component, and for the complete system chronologically. A continuous log shall be maintained for all devices. The log shall contain initial analog span and zero calibration values and digital points. Complete logs shall be kept and shall be available for inspection onsite, demonstrating that planned and systematic adjustments and repairs have been accomplished for the control system.

I. Work Requests: Each service call request shall be recorded as received and shall include the serial number identifying the component involved, its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. A record of the work performed shall be submitted within 5 days after work is accomplished.

J. System Modifications: Recommendations for system modification shall be submitted in writing. No system modifications, including operating parameters and control settings, shall be made without prior approval of the Government. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected.

K. Software: Updates to the software shall be provided for system, operating and application software, and operation in the system shall be verified. Updates shall be incorporated into operations and maintenance manuals, and software documentation. There shall be at least one scheduled update near the end of the first year's warranty period, at which time the latest released version of the Contractor's software shall be installed and validated.

1.07 SURGE PROTECTION

A. Power-Line Surge Protection: Equipment connected to ac circuits shall be protected against or withstand power-line surges. Equipment protection shall meet the requirements of IEEE C62.41. Fuses shall not be used for surge protection. DDC hardware shall be protected against or withstand surges induced on control and transmitter wiring installed outdoors and as shown. The equipment protection shall be tested in the normal mode and in the common mode, using the following two waveforms:

A 10-microsecond by 1,000-microsecond waveform with a peak voltage of 1,500 volts and a peak current of 60 amperes.

An eight microsecond by 20-microsecond waveform with a peak voltage of 1,000 volts and a peak current of 500 amperes.

1.08 BUILDING CONTROL NETWORK

A. The building control network shall consist of a backbone and one or more local control busses as specified.

Backbone Media: The backbone shall be a TP/FT-10 network in accordance with ANSI/EIA-709.3 or an IP network as specified in Section 13801 UTILITY MONITORING AND CONTROL SYSTEMS according to the following criteria:

a. The backbone shall be an IP network as specified in Section 13801 if both of the following conditions are met:

1) the Network Bandwidth Calculations for a heavily loaded network show that more than 70% of the 78kbps (kilobits per second) bandwidth is used or the Network and width Calculations for a normally loaded network show that more than 30% of the 78kbps bandwidth is used.

2) Tthe government has approved the Network Bandwidth Calculations submittal.

b. The backbone shall be a TP/FT-10 network otherwise.

Control Network Requirements: The control network shall meet the following requirements:

c. The backbone shall have no control devices connected to it. Only ANSI-709.1 routers and ANSI-709.3 to IP routers (as specified in Section 13801 UTILITY MONITORING AND CONTROL SYSTEMS) may be connected to the backbone.

d. The backbone shall be installed such that a router at the Building Point of Connection (BPOC) location may be connected to the backbone.

e. The local control bus shall use ANSI/EIA-709.1B over a TP/FT-10 network in doubly-terminated bus topology in accordance with ANSI/EIA-709.3

f. The local control busses shall be installed such that no node (device connected to the control network) has more than two ANSI-709.1 routers and ANSI-709.3 repeaters (in any combination) between it and the backbone, including the router connected to the backbone.

g. All DDC Hardware shall connect to a local control bus.

h. All DDD Hardware shall be locally powered; link power is not acceptable.

1.09 FACTORY TESTING

A. The Contractor shall assemble the factory test DDC system as specified and shall perform test to demonstrate that the performance of the system satisfies the requirements of this specification. Model numbers of equipment tested shall be identical to those to be delivered to the site. Original copies of data produced, including results of each test procedure during factory testing shall be delivered to the Government at the conclusion of testing, prior to Government approval of the test. The test results documentation shall be arranged so that commands, responses, and data acquired are correlated in a manner which will allow for logical interpretation of the data.

B. Factory Test Setup: The factory test setup shall include the following:
Central workstation/tester.
Printer.
DDC test set.
Portable workstation/tester.
Communication links of each type and speed including MODEMs.
Dial-up MODEM.
Software.

PART 2 PRODUCTS

2.01 GENERAL EQUIPMENT REQUIREMENTS

A. Units of the same type of equipment shall be products of a single manufacturer. Each major component of equipment shall have the manufacturer's name and address, and the model and serial number in a conspicuous place. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in a satisfactory commercial or industrial use for two years prior to use on this project. The two years' use shall include applications of equipment and materials under similar circumstances and of similar size. The two years' experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6,000 hours exclusive of the manufacturer's factory tests, can be shown. The equipment items shall be supported by a service organization. Items of the same type and purpose shall be identical, including equipment, assemblies, parts and components. Automatic temperature controls shall be direct digital controls that will provide the required sequence of operation.

B. Electrical and Electronic Devices: Electrical, electronic, and electropneumatic devices not located within a DDC panel shall have a NEMA ICS 1 enclosure in accordance with NEMA 250 unless otherwise shown.

C. Standard Signals: Except for air distribution terminal unit control equipment, the output of all analog transmitters and the analog input and output of all DDC controllers shall be 4-to-20 mAdc signals. The signal shall originate from current-sourcing devices and shall be received by current-sinking devices.

D. Ambient Temperature Limits: DDC panels shall have ambient condition ratings of 32 to 112 degrees F and 10 to 95 percent relative humidity, noncondensing. Devices installed outdoors shall operate within limit ratings of minus 35 to plus 151 degrees F. Instrumentation and control elements shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.

2.02 WIRING

A. Terminal Blocks: Terminal blocks shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

B. Control Wiring for 24-Volt Circuits: Control wiring for 24-volt circuits shall be 18 AWG minimum, stranded copper and shall be rated for 300-volt service.

C. Wiring for 120-Volt Circuits: Wiring for 120-volt circuits shall be 18 AWG minimum, stranded copper and shall be rated for 600-volt service.

D. Instrumentation Cable: Instrumentation cable shall be 18 AWG, stranded copper, single- or multiple-twisted, minimum 50 mm lay of twist, 100 percent shielded pairs, and shall have a 300-volt insulation. Each pair shall have a 20 AWG tinned-copper drain wire and individual overall pair insulation. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

E. Transformers: Step down transformers shall be utilized where control equipment operates at lower than line circuit voltage. Transformers, other than transformers in bridge circuits, shall have primaries wound for the

voltage available and secondaries wound for the correct control circuit voltage. Transformer shall be sized so that the connected load is 80 percent of the rated capacity or less. Transformers shall conform to UL 508 and NEMA ST 1.

2.03 ACTUATORS

A. Actuators shall be electric or electronic as shown and shall be provided with mounting and connecting hardware. Electric or electronic actuators shall be used for variable air volume (VAV) air terminal units. Actuators shall fail to their spring-return positions on signal or power failure, except that VAV terminal unit actuators may be of the floating type. The actuator stroke shall be limited in the direction of power stroke by an adjustable stop. Actuators shall have a visible position indicator. Actuators shall smoothly open or close the devices to which they are applied and shall have a full stroke response time of 90 seconds or less. Electric actuators shall be powered by a microprocessor controlled brushless DC motor. Electric or electronic actuators operating in series shall have an auxiliary actuator driver. Electric or electronic actuators used in sequencing applications shall have an adjustable operating range and start point.

B. Valve Actuators: Valve actuators shall be selected to provide a minimum of 125 percent of the motive power necessary to operate the valve over its full range of operation.

2.04 DAMPERS

A. Damper Assembly: A single damper section shall have blades no longer than 48” and shall be no higher than 72”. Maximum damper blade width shall be 8”. Larger sizes shall be made from a combination of sections. Dampers shall be steel, or other materials where shown. Flat blades shall be made rigid by folding the edges. Blade-operating linkages shall be within the frame so that blade-connecting devices within the same damper section shall not be located directly in the air stream. Damper axles shall be 1/2” minimum, plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically shall be supported by thrust bearings. Pressure drop through dampers shall not exceed 0.04” w.g. at 1000 fpm in the wide-open position. Frames shall not be less than 2” in width. Dampers shall be tested in accordance with AMCA 500-D.

B. Operating Links: Operating links external to dampers, such as crankarms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers, shall withstand a load equal to at least twice the maximum required damper-operating force. Rod lengths shall be adjustable. Links shall be brass, bronze, zinc-coated steel, or stainless steel. Working parts of joints and clevises shall be brass, bronze, or stainless steel. Adjustments of crankarms shall control the open and closed positions of dampers.

C. Damper Types: Dampers shall be parallel-blade type.
1. Outside Air, Return Air, and Relief Air Dampers: Outside air, return air and relief air dampers shall be provided where shown. Blades shall have interlocking edges and shall be provided with compressible seals at points of contact. The channel frames of the dampers shall be provided with jamb seals to minimize air leakage. Dampers shall not leak in excess of 20 cfm per square foot at 4” w.g static pressure when closed. Seals shall be suitable for an operating temperature range of minus 40 to plus 167 degrees F. Dampers shall be rated at not less than 10 m/s air velocity.
2. Mechanical and Electrical Space Ventilation Dampers: Mechanical and electrical space ventilation dampers shall be as shown. Dampers shall not leak in excess of 406 L/s per square meter at 1017 Pa static pressure when closed. Dampers shall be rated at not less than 2000 ft/min air velocity.
3. Smoke Dampers: Smoke-damper and actuator assembly required per NFPA 90A shall meet the Class II leakage requirements of UL 555S. Dampers shall be rated at not less than 10 m/s air velocity.

D. Damper End Switches: Each end switch shall be a hermetically sealed switch with a trip lever and over-travel mechanism. The switch enclosure shall be suitable for mounting on the duct exterior and shall permit setting the position of the trip lever that actuates the switch. The trip lever shall be aligned with the damper blade.

2.05 SMOKE DETECTORS: Duct smoke detectors shall be provided in supply and return air ducts in accordance with NFPA 90A. Duct smoke detectors shall conform to the requirements of UL 268A. Duct smoke detectors shall have perforated sampling tubes extended into the air duct. Detector circuitry shall be mounted in a metallic enclosure exterior to the duct. Detectors shall have manual reset. Detectors shall be rated for air velocities that include air flows between 500 and 4000

fpm. Detectors shall be powered from the fire alarm control panel (FACP). Detectors shall have two sets of normally open alarm contacts and two sets of normally closed alarm contacts. Detectors shall be connected to the building fire alarm panel for alarm initiation. A remote annunciation lamp and accessible remote reset switch shall be provided for duct detectors that are mounted eight feet or more above the finished floor and for detectors that are not readily visible. Remote lamps and switches as well as the affected fan units shall be properly identified in etched rigid plastic placards.

2.06 ENCLOSURES AND WEATHERSHIELDS

A. Enclosures: Enclosures shall meet the following minimum requirements:
1. Outdoors: Enclosures located outdoors shall meet NEMA 250 Type 3 requirements.
2. Mechanical and Electrical Rooms: Enclosures located in mechanical or electrical rooms shall meet NEMA 250 Type 2 requirements.
3. Other Locations: Enclosures in other locations including but not limited to occupied spaces, above ceilings, and plenum returns shall meet NEMA 250 Type 1 requirements. Enclosures supplied as an integral (pre-packaged) part of another product are acceptable.

B. Weathershields: Weathershields for sensors located outdoors shall prevent the sun from directly striking the sensor. The weathershield shall be provided with adequate ventilation so that the sensing element responds to the ambient temperature of the surroundings. The weathershield shall prevent rain from directly striking or dripping onto the temperature sensor. Weathershields installed near outside air intake ducts shall be installed such that normal outside air flow does not cause rainwater to strike the temperature sensor. Weathershields shall be constructed of galvanized steel painted white, aluminum or PVC.

2.07 NETWORK HARDWARE

A. ANSI-709 Network Hardware.
1. ANSI-709.1 Routers: ANSI-709.1 Routers (including routers configured as repeaters) shall meet the requirements of ANSI/EIA-709.1B and shall provide connection between two or more ANSI/EIA-709.3 TP/FT-10 channels.
2. ANSI-709.3 Repeaters: ANSI-709.3 Repeaters shall be physical layer repeaters in accordance with ANSI/EIA-709.3.
3. Gateways: Gateways shall perform bi-directional protocol translation to one non-ANSI/EIA-709.1 protocol to ANSI/EIA-709.1B. Gateways shall incorporate exactly two network connections: one shall be for connection to a TP/FT-10 network in accordance with ANSI/EIA-709.3 and the second shall be as required to communicate with the non-ANSI/EIA-709.1 network.

2.08 WIRING

A. Terminal Blocks: Terminal blocks which are not integral to other equipment shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

B. Control Wiring for Binary Signals: Control wiring for binary signals shall be 18 AWG copper and shall be rated for 300-volt service.

C. Wiring for 120-Volt Circuits: Wiring for 120-volt circuits shall be 18 AWG or thicker stranded copper and shall be rated for 600-volt service.

D. Control Wiring for Analog Signals: Control Wiring for Analog Signals shall be 18 AWG, copper, single- or multiple-twisted, minimum 50mm (2inch)lay of twist, 100% shielded pairs, and shall have a 300-volt insulation. Each pair shall have a 20 AWG tinned-copper drain wire and individual overall pair insulation. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

E. Transformers: Transformers shall be UL 1585 approved. Transformers shall be sized so that the connected load is no greater than 80% of the transformer rated capacity.

2.09 INSTRUMENTATION

A. Measurements: Transmitters shall be calibrated to provide the following measurements, over the indicated ranges, for an output of 4 to 20 mAdc:
1. Conditioned space temperature, from 50 to 86 degrees F.
2. Duct temperature, from 40 to 140 degrees F.
3. Outside-air temperature, from minus -40 to 130 degrees F.
4. Relative humidity, 0 to 100 percent for space and duct high-limit applications.
5. Differential pressure for VAV supply-duct static pressure from 0 to 6" w.g.

B. Temperature Instruments:
1. Resistance Temperature Detectors (RTD): Temperature sensors shall be 100 ohms 3- or 4-wire RTD. Each RTD shall be platinum with a tolerance of 0.06 degrees F at 32 degrees F with a temperature coefficient of resistance (TCR) of 0.00385 ohms/ohm/deg C and shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper. Each RTD shall be furnished with an RTD transmitter as specified, integrally mounted unless otherwise shown.
2. Continuous Averaging RTD: Continuous averaging RTDs shall have a tolerance of plus or minus 1 degree F at the reference temperature, and shall be of sufficient length to ensure that the resistance represents an average over the cross section in which it is installed. The sensing element shall have a bendable copper sheath. Each averaging RTD shall be furnished with an RTD transmitter to match the resistance range of the averaging RTD.
3. RTD Transmitter: The RTD transmitter shall match the resistance range of the RTD. The transmitter shall be a two-wire, loop powered device. The transmitter shall produce a linear 4-to-20 mAdc output corresponding to the required temperature measurement. The output error shall not exceed 0.1 percent of the calibrated measurement.

C. Relative Humidity Instruments: A relative-humidity instrument for indoor application shall have a measurement range from 0 to 100 percent relative-humidity and be rated for operation at ambient air temperatures within the range of minus 4 to plus 55 degrees C. It shall be capable of being exposed to a condensing air stream (100 percent RH) with no adverse effect to the sensor's calibration or other harm to the instrument. The instrument shall be of the wall-mounted or duct-mounted type, as required by the application, and shall be provided with any required accessories. Instruments used in duct high-limit applications shall have a bulk polymer resistive sensing element. Duct-mounted instruments shall be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. The instrument (sensing element and transmitter) shall be a two-wire, loop-powered device and shall have an accuracy of plus or minus three percent of full scale within the range of 20 to 80 percent relative humidity. The instrument shall have a typical long-term stability of 1 percent or less drift per year. The transmitter shall convert the sensing element's output to a linear 4-20 mAdc output signal in proportion to the measured relative-humidity value. The transmitter shall include offset and span adjustments.

D. Differential Pressure Instruments: The instrument shall be a pressure transmitter with an integral sensing element. The instrument over pressure rating shall be 300 percent of the operating pressure. The sensor/transmitter assembly accuracy shall be plus or minus two percent of full scale. The transmitter shall be a two-wire, loop-powered device. The transmitter shall produce a linear 4-to-20 mAdc output corresponding to the required pressure measurement.

E. Thermowells: Thermowells shall be Series 300 stainless steel with threaded brass plug and chain, 2" lagging neck and extension type well. Inside diameter and insertion length shall be as required for the application and tagged with inside diameter and depth.

2.10 THERMOSTATS

A. Thermostat ranges shall be selected so that the setpoint is adjustable without tools between plus or minus 9 degrees F of the setpoint shown. Thermostats shall be electronic or electric.

B. Nonmodulating Room Thermostats: Contacts shall be single-pole double-throw (SPDT), hermetically sealed, and wired to identified terminals. Maximum differential shall be 5 degrees F. Room thermostats shall be enclosed with separate locking covers (guards).

C. Microprocessor Based Room Thermostats: Microprocessor based thermostats shall have built-in keypads for scheduling of day and night temperature settings. When out of the scheduling mode, thermostats shall have continuous display of time, with AM and PM indicator, continuous display of day of week, and either continuous display of room temperature with display of temperature setpoint on demand, or continuous display of

temperature setpoint with display of room temperature on demand. In the programmable mode, the display shall be used for interrogating time program ON-OFF setpoints for all seven days of the week. The time program shall allow two separate temperature setback intervals per day. The thermostats shall have a means for temporary and manual override of the program schedule, with automatic program restoration on the following day. Thermostats shall have a replaceable battery to maintain the timing and maintain the schedule in memory for one year in the event of a power outage. Maximum differential shall be 2 degrees F. When used for heat pump applications, the thermostat shall have an emergency heat switch.

D. Modulating Room Thermostats: Modulating room thermostats shall have either one output signal, two output signals operating in unison, or two output signals operating in sequence, as required for the application. Each thermostat shall have an adjustable throttling range of 4 to 8 degrees F for each output. Room thermostats shall be enclosed with separate locking covers (guards).

E. Nonmodulating Capillary Thermostats and Aquastats: Each thermostat shall have a capillary length of at least 60", shall have adjustable direct-reading scales for both setpoint and differential, and shall have a differential adjustable from 6 to 18 degrees F. Aquastats shall be of the strap on type, with 5 degrees C fixed differential.

F. Freezestats: Freezestats shall be manual reset, low temperature safety thermostats, with NO and NC contacts and a 240" element which shall respond to the coldest 18" segment.

G. Modulating Capillary Thermostats: Each thermostat shall have either one output signal, two output signals operating in unison, or two output signals operating in sequence, as required for the application. Thermostats shall have adjustable throttling ranges of 4 to 8 degrees F for each output.

2.11 PRESSURE SWITCHES AND SOLENOID VALVES

A. Pressure Switches: Each switch shall have an adjustable setpoint with visible setpoint scale. Range shall be as shown. Differential adjustment shall span 20 to 40 percent of the range of the device.

B. Differential-Pressure Switches: Each switch shall be an adjustable diaphragm-operated device with two SPDT contacts, with taps for sensing lines to be connected to duct pressure fittings designed to sense air pressure. These fittings shall be of the angled-tip type with tips pointing into the air stream. The setpoint shall not be in the upper or lower quarters of the range and the range shall not be more than three times the setpoint. Differential shall be a maximum of 0.14" w.g. at the low end of the range and .34" w.g. at the high end of the range.

2.12 INDICATING DEVICES

A. Thermometers: Mercury shall not be used in thermometers and must be replaced.
   1. Nonaveraging Air-Duct Thermometers: Air-duct thermometers shall have perforated stem guards and 45-degree adjustable duct flanges with locking mechanism.
   2. Averaging Air-Duct Thermometers: Averaging thermometers shall have a 3-1/2" (nominal) dial, with black legend on white background, and pointer traveling through a 270-degree arc.
   3. Accuracy: Thermometers shall have an accuracy of plus or minus one percent of scale range. Thermometers shall have a range suitable for the application.

B. Pressure Gauges: Gauges shall be 2" (nominal) size, back connected, suitable for field or panel mounting as required, shall have black legend on white background, and shall have a pointer traveling through a 270-degree arc. Accuracy shall be plus or minus three percent of scale range. Gauges shall meet requirements of ASME B40.100.

2.13 CONTROL DEVICES AND ACCESSORIES

A. Relays: Control relay contacts shall have utilization category and ratings selected for the application, with a minimum of two sets of contacts (two normally open, two normally closed) enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150 percent of rated coil voltage. Time delay relays shall be 2PDT with eight-pin connectors, dust cover, and a matching rail-

mounted socket. Adjustable timing range shall be 0 to 5 minutes. Power consumption shall not be greater than three watts.

B. Joule or Watthour Meters: Joule meters shall be in accordance with ANSI C12.1 and have pulse initiators for remote monitoring of Joule consumption. Pulse initiator shall consist of form C contacts with a current rating not to exceed two amperes and voltage not to exceed 500 V, with combinations of VA not to exceed 100 VA, and a life rating of one billion operations. Meter sockets shall be in accordance with ANSI C12.1.

C. Joule or Watthour Meters with Demand Register: Meters shall be in accordance with ANSI C12.1 and shall have pulse initiators for remote monitoring of Joule consumption and instantaneous demand. Pulse initiators shall consist of form C contacts with a current rating not to exceed two amperes and voltage not to exceed 500 V, with combinations of VA not to exceed 100 VA, and a life rating of one billion operations. Meter sockets shall be in accordance with ANSI C12.1

D. Joule or Watthour Transducers: Joule transducers shall have an accuracy of plus or minus 0.25 percent for kW and Joule outputs from full lag to full lead power factor. Input ranges for kW and Joule transducers shall be selectable without requiring the changing of current or potential transformers. The output shall be 4 to 20 mAdc.

E. Current Sensing Relays: Current sensing relays shall provide a normally-open contact rated at a minimum of 50 volts peak and 1/2 ampere or 25 VA, noninductive. There shall be a single hole for passage of current carrying conductors. The devices shall be sized for operation at 50 percent rated current based on the connected load. Voltage isolation shall be a minimum of 600 volts.

F. Power-Line Conditioners (PLC)

1. Power line conditioners shall be furnished for each DDC panel. The PLCs shall provide both voltage regulation and noise rejection. The PLCs shall be of the ferro-resonant design, with no moving parts and no tap switching, while electrically isolating the secondary from the power-line side. The PLCs shall be sized for 125 percent of the actual connected kVA load. Characteristics of the PLC shall be as follows:
   a. At 85 percent load, the output voltage shall not deviate by more than plus or minus one percent of nominal when the input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
   b. During load changes of zero to full load, the output voltage shall not deviate by more than plus or minus three percent of nominal voltage. Full correction of load switching disturbances shall be accomplished within five cycles, and 95 percent correction shall be accomplished within two cycles of the onset of the disturbance.
   c. Total harmonic distortion shall not exceed 3-1/2 percent at full load.

G. Carbon Dioxide Sensors Carbon Dioxide (CO_2) Sensors

1. Sensor shall employ non-dispersive infrared technology (N.D.I.R.) and shall have a 0-2000 ppm range.
2. Sensor repeatability shall be ± 8 ppm and accuracy shall be <= 75 ppm over 0-1500 range, and a response time of less than 1 minute.
3. Sensor shall employ reference channel design for long term stability.
4. Sensor shall have field selectable 0-10VDC, 0-5VDC or 4-20mA output.
5. Sensor power requirement shall be less than 3W.
6. Sensor input voltage shall be 20 to 30VAC/DC.
7. Sensor operating temperature range shall be 0° C to 50° C.
8. Sensor shall have provision for duct mounting.
9. Sensor shall be Veris Industries DC Series or equal.

H. Damper End Switches: Each end switch shall be hermetically sealed with a trip lever and over-travel mechanism. The switch enclosure shall be suitable for mounting on the duct exterior and shall permit setting the position of the trip lever that actuates the switch. The trip lever shall be aligned with the damper blade.

2.14 USER INPUT DEVICES

A. User Input Devices with SNVT output shall be considered Application Specific Controllers and meet all requirements thereof in addition to the user input device requirements.

1. Potentiometer: The Potentiometer shall be of the thumb wheel or sliding bar type and shall be clearly labeled for increase or decrease or it's output.
2. Switch: Switches shall be clearly labeled in a permanent fashion to show their intended function.
3. Momentary Contact Push-Button: Momentary contact push-buttons may include an adjustable timer for their output.

2.15 DIRECT DIGITAL CONTROL (DDC) HARDWARE

A. General Requirements: All DDC Hardware shall meet the following requirements:
1. It shall incorporate a "service pin" which, when pressed will cause the DDC Hardware to broadcast its 48-bit NodeID and its ProgramID over the network. The service pin shall be distinguishable and accessible.
2. It shall incorporate a light indicating power.
3. It shall incorporate a TP/FT-10 transceiver in accordance with ANSI/EIA-709.3 and connections for TP/FT-10 control network wiring. It shall not have connections to any other media type.
4. It shall communicate on the network using only the ANSI/EIA-709.1B protocol.
5. It shall be locally powered, link powered devices are not acceptable.
6. LonMark external interface files (XIF files) as defined in the LonMark XIF Guide shall be submitted for each type of DDC hardware.
7. Application program shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration parameter settings.
8. It shall have all functionality specified and required to support the Sequence of Operation and application in which it is used, including but not limited to:
   a. It shall provide input and output SNVTs as specified and required to support the sequence and application in which it is used.
   b. It shall be configurable via standard or user-defined configuration parameters (SCPT) or hardware settings on the controller itself specified and as required to support the sequence and application in which it is used.
9. It shall meet FCC Part 15 requirements and have UL 916 or equivalent safety listing.

B. Hardware Input-Output (I/O) Functions: DDC Hardware incorporating hardware input-output (I/O) functions shall meet the following requirements:
1. Analog Inputs: DDC Hardware analog inputs (AIs) shall perform analog to digital (A-to-D) conversion with a minimum resolution of 12 bits plus sign. Signal conditioning including transient rejection shall be provided for each analog input. Analog inputs shall be individually calibrated for zero and span, in hardware or in software. The AI shall incorporate common mode noise rejection of 50 dB from 0 to 100 Hz for differential inputs, and normal mode noise rejection of 20 dB at 60 Hz from a source impedance of 10,000 ohms.
2. Analog Outputs: DDC Hardware analog outputs (AOs) shall perform digital to analog (D-to-A) conversion with a minimum resolution of 12 bits plus sign, and output a signal within the range of 4-20mADC or 0-10VDC. Analog outputs shall be individually calibrated for zero and span.
3. Binary Inputs: DDC Hardware binary inputs (BIs) shall accept contact closures and shall ignore transients of less than 5 milli-second duration. Isolation and protection against an applied steady-state voltage up to 180VAV peak shall be provided.
4. Binary Outputs: DDC Hardware binary outputs (BOs) shall provide relay contact closures or triac outputs for momentary and maintained operation of output devices.
   a. Relay Contact Closures: Closures shall have a minimum duration of 0.1 second. BO relays shall provide at least 180V of isolation. Electromagnetic interference suppression shall be furnished on all output lines to limit transients to nondamaging levels. Minimum contact rating shall be one ampere at 24VAC.
   b. Triac outputs: Triac outputs shall provide at least 180V of isolation.
5. Pulse Accumulator: DDC Hardware pulse accumulators shall have the same characteristics as the BI. In addition, a buffer shall be provided to totalize pulses. The pulse accumulator shall accept rates up to 20 pulses per second. The totalized value shall be reset to zero upon operator's command.

C. Application Specific Controller (ASC): Application Specific Controllers (ASCs) have a fixed factory-installed application program (ie ProgramID) with configurable settings. ASCs shall meet the following requirements in addition to the general DDC Hardware and DDC Hardware Input-Output (I/O) Function requirements:
1. ASCs shall be LonMark Certified.
2. All necessary configuration parameters for the sequence and application in which the ASC is used shall be fully configurable through an LNS plug-in. This plug-in shall be submitted for each ASC

installed as specified. (Note that sensors and actuators fully configurable through hardware settings do not not require a plug-in)

a. Local Display Panel (LDP) : The Local Display Panel shall be a wall-mountable Application Specific Controller with a display and navigation buttons. It shall have SNVT inputs which an operator can select to display, and SNVT outputs which the operator can both display and change the value of.

D. General Purpose Programmable Controller (GPPC): A General Purpose Programmable Controller (GPPC) is not installed with a fixed factory-installed application program. GPPCs shall meet the following requirements in addition to the general DDC Hardware requirements and Hardware Input-Output (I/O) Function:

1. The programmed GPPC shall conform to the LonMark Interoperability Guide.
2. All programming software required to program the GPPC shall be submitted as specified.
3. Copies of the installed GPPC application programs in machine readable form compatible with the supplied programming software shall be submitted as specified. The submitted GPPC application program shall be the complete application necessary for the GPPC to function as installed.

E. Communication Interfaces: The following communication capabilities shall function simultaneously.

1. Manufacturers Control Network. Manufacturers control network communications interfaces for each data transmission systems (DTS) circuit between network control panels and RIUs, unitary controllers, and universal programmable controllers, shall be provided. Communication interfaces shall be provided between each network control panel and associated I/O functions. The DTS will provide for transmission speeds necessary to comply with performance requirements specified. DTS equipment shall be installed in the network control panel enclosure.
2. Portable Workstation/Tester Port. A communications port for interfacing to a portable workstation/tester shall be provided. Network control panel workstation/tester port other than RS-232,shall be converted to RS-232, including cabling and power supply, and shall be permanently installed in the panel.
3. Primary Network Port. The network control panel shall either have a built in primary network Port or be capable of accepting a primary network port expansion card for future networking to a base wide utility monitoring and control system (UMCS). The primary network port expansion card shall be either Ethernet (IEEE802.3) or ARCNET.

F. Memory and Real Time Clock (RTC) Backup: The network control panel memory and real time clock functions shall continue to operate for a minimum of 72 hours in the event of a power failure. If rechargeable batteries are provided, automatic charging of batteries shall be provided. Whenever a either a permanent workstation/tester or portable workstation/tester is monitoring the network control panel, a low battery alarm message shall be sent to it.

G. Duplex Outlet: A single phase, 120 Vac electrical service outlet for use with test equipment shall be furnished either inside or within 2 meters of the network control panel enclosure.

H. Locking Enclosures: Locking type mounting cabinets with common keying shall be furnished for each network control panel.

I. Failure Mode: Upon failure of the network control panel, either due to failure of the network control panel hardware or of the manufacturers control network, the network control panel shall revert to the failure mode as shown.

1. Manufacturers Control Network Failure: Upon failure of the manufacturers control network, the network control panel shall operate in an independent stand-alone mode.
2. Network Control Panel Hardware Failure: Upon failure of the network control panel hardware, the network control panel shall cease operation and stop communications with other network control panels, RIUs, unitary controllers and universal programmable controllers connected to the affected network control panel. The affected network control panel shall respond to this failure as specified and shown.

J. DDC Hardware I/O Functions: I/O Functions shall be provided as part of the DDC system and shall be in accordance with the following:

1. The analog input (AI) function shall monitor each analog input, perform A-to-D conversion, and hold the digital value in a buffer for interrogation. The A-to-D conversion shall have a minimum resolution of 10 bits plus sign. Signal conditioning shall be provided for each analog input. Analog inputs shall be individually calibrated for zero and span, in hardware or in software. The AI shall incorporate common mode noise rejection of 50 dB from 0 to 100 Hz for differential inputs, and normal mode

noise rejection of 20 dB at 60 Hz from a source impedance of 10,000 ohms. Input ranges shall be within the range of 4-to-20 mAdc.

2. The analog output (AO) function shall accept digital data, perform D-to-A conversion, and output a signal within the range of 4-to-20 mAdc. D-to-A conversion shall have a minimum resolution of eight bits plus sign. Analog outputs shall be individually calibrated for zero and span. Short circuit protection on voltage outputs and open circuit protection on current outputs shall be provided. An individual gradual switch for manual override of each analog output and means of physically securing access to these switches shall be provided. Each AO shall have a three-position switch for selection of the DDC control signal, no control, or a locally generated control signal for connection to the controlled device. Feedback shall be provided to the system as to the status of the output (manual control or automatic). All switches shall be either of a key operated design with the same keying system used for other outputs or otherwise suitably protected from unauthorized access.
3. The digital input (DI) function shall accept on-off, open-close, or other change of state (two state data) indications. Isolation and protection against an applied steady-state voltage up to 180 Vac peak shall be provided.
4. The digital output (DO) function shall provide contact closures for momentary and maintained operation of output devices. Closures shall have a minimum duration of 0.1 second. DO relays shall have an initial breakdown voltage between contacts and coil of at least 500 V peak. Electromagnetic interference suppression shall be furnished on all output lines to limit transients to nondamaging levels. Protection against an applied steady-state voltage up to 180 Vac peak shall be provided. Minimum contact rating shall be one ampere at 24 Vac.
5. The pulse accumulator function shall have the same characteristics as the DI. In addition, a buffer shall be provided to totalize pulses and allow for interrogation by the DDC system. The pulse accumulator shall accept rates up to 20 pulses per second. The totalized value shall be reset to zero upon operator's command.
6. Signal conditioning for sensors shall be provided as specified.
7. The binary coded decimal (BCD) function: The BCD function shall have the same characteristics as the DI, except that, in addition, a buffer shall be provided to totalize inputs and allow for interrogation by the network control panel. The BCD function shall have 16-channel optically isolated buffered inputs to read four digit numbers. The BCD function shall accumulate inputs at rates up to 10 inputs per second.

K. Failure Mode: Upon failure of the I/O function, including data transmission failure, logic power supply failure, DDC processor malfunction, software failure, interposing relay power failure, or any other failure which prevents stand alone operation of any DDC normally capable of stand alone operation, connected outputs shall be forced to the failure mode shown.

L. Portable Workstation/Tester: A portable workstation/tester shall be provided and shall be able to connect to any DDC hardware. The portable workstation/tester shall consist of a portable computer (GFM) with a nominal 13.3 inches active color matrix liquid crystal display, capable of displaying up to 256 colors at a minimum resolution of 1366 X 768 resolution with 1.6 GB graphics memory, dual core microprocessor operating at a minimum of 2.3 GHz with 3MB cache. The portable workstation/tester shall have, as a minimum, a 640 GB hard drive, 4 gigabytes of memory, integral pointing device, wireless LAN 802.11b,g,n, (1) VGA 15-pin port, (3) USB 2.0 ports, (1) HDMI port, (2) audio ports, (1) Lan RJ-45 port for 10/100 Mbps Ethernet communication, memory card reader, blue ray player/CR-RW/DVD- RW, rechargeable battery, battery charger/120 VAC power supply, with the most updated and appropriate operating system for the DDC and UMC systems.. It shall include carrying case, extra battery, charger. The workstation/tester shall:

1. Run DDC diagnostics.
2. Load all DDC memory resident programs and information, including parameters and constraints.
3. Display any AI, DI, AO, DO, or PA point in engineering units for analog points or status for digital points.
4. Control any AO or DO.
5. Provide an operator interface, contingent on password level, allowing the operator to use full English language words and acronyms, or an object oriented graphical user interface.
6. Display database parameters.
7. Modify database parameters.
8. Accept DDC software and information for subsequent loading into a specific DDC. Provide all necessary software and hardware required to support this function, including an EIA ANSI/EIA/TIA-232-F port.
9. Disable/enable each DDC.
10. Perform all workstation functions as specified.

M. Central Workstation/Tester: A central workstation/tester shall be provided and shall be able to communicate any network control panel via the primary network. The central workstation/tester shall be functionally equivalent to the portable workstation/tester but is intended to be a stationary unit. The central workstation shall consist of a desktop computer with a nominal 20 inches widescreen HD liquid crystal display/LED backlight, maximum resolution of 1600 X 900 resolution, 5 ms response, The desktop computer shall have dual core microprocessor operating at a minimum of 3.1 GHz with 3MB cache, a minimum, a 1 TB 7200 rpm hard drive, 6 gigabytes of memory, 1.0 GB graphics memory having VGA/HDMI/DVI interfaces, USB mouse, USB keyboard, (1) VGA 15-pin port, (6) USB 2.0 (2) USB 3.0 back & (2) USB 2.0 front ports, (1) HDMI port, , (2) audio ports, (1) Lan RJ-45 port for 10/100/1000 Mbps Ethernet communication, (1) PCIe X16 slot, (3) PCIe X1 slots, 8-in-1 media card reader, blue ray player/CR-RW/DVD- RW, and wireless 802.11b,g,n minicard with the most updated and appropriate operating system for the DDC and UMC systems. An uninterruptable power supply (UPS) sized for minimum 30 minutes operation shall be provided for the central workstation. The central workstation/tester shall:

1. Run DDC diagnostics.
2. Load all DDC memory resident programs and information, including parameters and constraints.
3. Display any AI, DI, AO, DO, or PA point in engineering units for analog points or status for digital points.
4. Control any AO or DO.
5. Provide an operator interface, contingent on password level, allowing the operator to use full English language words and acronyms, or an object oriented graphical user interface.
6. Display database parameters.
7. Modify database parameters.
8. Accept DDC software and information for subsequent loading into a specific DDC. Provide all necessary software and hardware required to support this function, including an EIA ANSI/EIA/TIA-232-F port.
9. Disable/enable each DDC.
10. Perform all workstation functions as specified.

N. Data Terminal Cabinet (DTC): The DTC shall be an independent metallic enclosure not physically part of the network control panel/RIU as shown. The DTC shall be sized to accommodate the number of I/O functions required for each network control panel/RIU, including installed spares, plus 10% expansion for each type of I/O function provided. The DTC shall be divided into analog input and output groups and digital input and output groups. The DTC shall be provided with double sided screw type terminal strips. One side of the terminal strip shall be used for termination of field wiring from instrumentation and controls. The other side shall be used to connect the DTC to the network control panel/RIU. Terminal strips shall have individual terminal identification numbers. The DTC shall be a locking type mounting enclosure, with common keying and door switch wired to an input for intrusion alarm annunciation at the central station. DTC keying shall be identical to network control panel/RIU keying.

2.16 DDC SOFTWARE

A. All DDC software described in this specification shall be furnished as part of the complete DDC System.

1. Operating System: Each DDC shall contain an operating system that controls and schedules that DDC's activities in real time. The DDC shall maintain a point database in its memory that includes all parameters, constraints, and the latest value or status of all points connected to that DDC. The execution of DDC application programs shall utilize the data in memory resident files. The operating system shall include a real time clock function that maintains the seconds, minutes, hours, date and month, including day of the week. Each DDC real time clock shall be automatically synchronized with the network control panel real time clock at least once per day to plus or minus 10 seconds. When the network control panel is connected to a central workstation/tester, the network control panel RTC shall be updated by the central workstation/tester RTC. The time synchronization shall be accomplished without operator intervention and without requiring system shutdown. The operating system shall allow loading of software, data files data entry, and diagnostics from the central workstation/tester both locally through the central workstation/tester port and remotely through a network control panel and the manufacturers control network.
2. Startup: The DDC shall have startup software that causes automatic commencement of operation without human intervention, including startup of all connected I/O functions. A DDC restart program based on detection of power failure at the DDC shall be included in the DDC software. Upon restoration of power to the DDC, the program shall restart equipment and restore loads to the state at time of power failure, or to the state as commanded by time programs or other overriding programs. The restart program shall include start time delays between successive commands to prevent

demand surges or overload trips. The startup software shall initiate operation of self-test diagnostic routines. Upon failure of the DDC, if the database and application software are no longer resident or if the clock cannot be read, the DDC shall not restart and systems shall remain in the failure mode indicated until the necessary repairs are made. If the database and application programs are resident, the DDC shall resume operation after an adjustable time delay of from 0 to 600 seconds. The startup sequence for each DDC shall include a unique time delay setting for each control output when system operation is initiated.

3. Operating Mode: Each DDC shall control and monitor functions as specified, independent of communications with other DDC. This software shall perform all DDC functions and DDC resident application programs as specified using data obtained from I/O functions and based upon the DDC real time clock function. When communications circuits between the DDC are operable, the DDC shall obtain real time clock updates and any required global data values transmitted from other network control panels. The DDC software shall execute commands after performing constraints checks in the DDC. Status and analog values, including alarms and other data shall be transmitted from other network control panels when communications circuits are operable. If communications are not available, each DDC shall function in stand-alone mode and operational data, including the latest status and value of each point and results of calculations, normally transmitted from other network control panels shall be stored for later transmission to the network control panel. Storage for the latest 256 values shall be provided at each network control panel. Each DDC shall accept software downloaded from the network control panel. Constraints shall reside at the DDC.
4. Failure Mode: Upon failure for any reason, each DDC shall perform an orderly shutdown and force all DDC outputs to a predetermined (failure mode) state, consistent with the failure modes shown and the associated control device.

B. Functions: The Contractor shall provide software necessary to accomplish the following functions, as appropriate, fully implemented and operational, within each network control panel, RIU, unitary controller and universal programmable controller.

- Scanning of inputs.
- Control of outputs.
- Reporting of analog changes outside a selectable differential.
- Reporting of unauthorized digital status.
- Reporting of alarms automatically to network control panel.
- Reporting of I/O status to network control panel upon request.
- Maintenance of real time, updated by the network control panel at least once a day.
- Communication with the network control panel.
- Execution of DDC resident application programs.
- Averaging or filtering of AIs.
- Constraints checks (prior to command issuance).
- Diagnostics.
- Portable workstation/tester operation as specified.
- Reset of PA by operator based on time and value.

1. Analog Monitoring: The system shall measure and transmit analog values including calculated analog points. An analog change in value is defined as a change exceeding a preset differential value as specified. The record transmitted for each analog value shall include a readily identifiable flag which indicates the abnormal status of the value when it deviates from operator selectable upper and lower analog limits. Analog values shall be expressed in proper engineering units with sign. Engineering units conversions shall be provided for each measurement. Each engineering units conversion set shall include range, span, and conversion equation. A vocabulary of engineering unit descriptors shall be provided, using at least three alphanumeric characters to identify information in the system. The system shall support 255 different engineering units.
2. Logic (Virtual) Points: Logic (virtual) points shall be software points entered in the point database which are not directly associated with a physical I/O function. Logic (virtual) points shall be analog or digital points created by calculation from any combination of digital and analog points, or other data having the properties of real points, including alarms, without the associated hardware. Logic (virtual) points shall be defined or calculated and entered into the database by the Contractor. The calculated analog point shall have point identification in the same format as any other analog point. The calculated point shall be used in any program where the real value is not obtainable directly. Constants used in calculations shall be changeable on-line by the operator. Calculated point values shall be current for use by the system within 10 seconds of the time of any input changes.

3. State Variables: If an analog point represents more than two (up to eight) specific states, each state shall be nameable. For example, a level sensor shall be displayed at its measured engineering units plus a state variable with named states usable in programs or for display such as low alarm/low/normal/high/high alarm.
4. Analog Totalization: Any analog point shall be operator assignable to the totalization program. Up to eight analog values shall be totalized within a selectable time period. At the end of the period, the totals shall be stored. Totalization shall then restart from zero for the next time period. The program shall keep track of the peak and total value measured during the current period and for the previous period. The operator shall be able to set or reset each totalized value individually. The time period shall be able to be operator defined, modified or deleted on-line.
5. Energy Totalization: The system shall calculate the heat energy in Btus, for each energy source consumed by the mechanical systems specified, totalize the calculated Btus, the instantaneous rate in Btus per hour, and store totals in thousands of Btus (MBtu). The Btus calculated shall be totalized for an adjustable time period. The time period shall be defined uniquely for each Btu totalization.
6. Trending: Any analog or calculated point shall be operator assignable to the trend program. Up to eight points shall be sampled at individually assigned intervals, selectable between one minute and two hours. A minimum of the most recent 128 samples of each trended point shall be stored. The sample intervals shall be able to be defined, modified, or deleted on-line.

C. I/O Point Database/Parameter Definition: Each I/O point shall be defined in a database residing in the DDC. The definition shall include all physical parameters associated with each point. Each point shall be defined and entered into the database by the Contractor, including as applicable:
1. Name.
2. Device or sensor type (i.e., sensor, control relay, motors).
3. Point identification number.
4. Unit.
5. Building number.
6. Area.
7. Island.
8. DDC number and channel address.
9. KW (running).
10. KW (starting).
11. Sensor range.
12. Controller range.
13. Sensor span.
14. Controller span.
15. Engineering units conversion (scale factor).
16. Setpoint (analog).
17. High reasonableness value (analog).
18. Low reasonableness value (analog).
19. High alarm limit differential (return to normal).
20. Low alarm limit differential (return to normal).
21. High alarm limit (analog).
22. Low alarm limit (analog).
23. Alarm disable time period upon startup or change of setpoint.
24. Analog change differential (for reporting).
25. Alarm class and associated primary message text.
26. High accumulator limit (pulse).
27. Status description.
28. Run time target.
29. Failure mode as specified and shown.
30. Constraints as specified.

D. Alarm Processing: Each DDC shall have alarm processing software for AI, DI, and PA alarms for all real and virtual points connected to that DDC.
1. Digital Alarms Definition: Digital alarms are those abnormal conditions indicated by DIs as specified and shown.
2. Analog Alarms Definition: Analog alarms are those conditions higher or lower than a defined value, as measured by an AI. Analog readings shall be compared to predefined high and low limits, and alarmed each time a value enters or returns from a limit condition. Unique high and low limits shall be assigned to each analog point in the system. Analog alarm limits shall be stored in the DDC database. Each analog alarm limit shall have an associated unique limit differential specifying the

amount by which a variable must return into the proper operating range before being annunciated as a return-to-normal-state. All limits and differentials shall be entered on-line by the operator in limits of the measured variable, without interruption or loss of monitoring of the point concerned. The program shall automatically change the high or low limits or both, of any analog point, based on time scheduled operations as specified, allowing for a time interval before the alarm limit becomes effective. In CPA applications, key the limit to a finite deviation traveling with the setpoint. The system shall automatically suppress analog alarm reporting associated with a digital point when that digital point is turned off.

3. Pulse Accumulator Alarms Definition: Pulse accumulator alarms are those conditions calculated from totalized values of accumulator inputs or PA input rates that are outside defined limits as specified and shown. PA totalized values shall be compared to predefined limits and alarmed each time a value enters a limit condition. Unique limits shall be assigned to each PA point in the system. Limits shall be stored in the DDC database.

E. Constraints

1. Equipment Constraints Definitions: Each control point in the database shall have DDC resident constraints defined and entered by the Contractor, including as applicable:
   a. Maximum starts (cycles) per hour.
   b. Minimum off time.
   c. Minimum on time.
   d. High limit (value in engineering units).
   e. Low limit (value in engineering units).
2. Constraints Checks: Control devices connected to the system shall have the DDC memory resident constraints checked before each command is issued to insure that no equipment damage will result from improper operation. Each command shall be executed by the DDC only after all constraints checks have been passed. Each command point shall have unique constraints assigned. High and low "reasonableness" values or one differential "rate-of-change" value shall be assigned to each AI. Values outside the reasonableness limits shall be rejected and an alarm message sent to the network control panel or portable workstation/tester. Status changes and analog point values shall be reported to the workstation upon operator request, such as for reports, alphanumeric displays, graphic displays, and application programs. Each individual point shall be capable of being selectively disabled by the operator from a workstation/tester. Disabling a point shall prohibit monitoring and automatic control of that point.

F. Diagnostics: Each DDC shall have self-test diagnostic routines implemented in firmware. The tests shall include routines that exercise memory. Diagnostic software shall be usable in conjunction with the central workstation/tester and portable workstation/tester. The software shall display messages in English to inform the tester's operator of diagnosed problems.

G. Summer-Winter Operation Monitoring: The system shall provide software to automatically change the operating parameters, monitoring of alarm limits, and start-stop schedules for each mechanical system from summer to winter and vice-versa. The software shall provide automatic commands to applications programs to coordinate proper summer or winter operation. Change over setpoints shall be operator selectable and settable.

H. Control Sequences and Control Loops: Sufficient memory shall be provided to implement the requirements specified and shown for each DDC. Specific functions to be implemented are defined in individual system control sequences and database tables shown in the drawings, and shall include, as applicable, the following:

1. PI Control: This function shall provide proportional control and proportional plus integral control.
2. Two Position Control: This function shall provide control for a two state device by comparing a set point against a process variable and an established deadband.
3. Floating Point Control: This function shall exercise control when an error signal exceeds a selected deadband, and shall maintain control until the error is within the deadband limits.
4. Signal Selection: This function shall allow the selection of the highest or lowest analog value from a group of analog values as the basis of control. The function shall include the ability to cascade analog values so that large numbers of inputs can be reduced to one or two outputs.
5. Signal Averaging: This function shall allow the mathematical calculation of the average analog value from a group of analog values as the basis of control. The function shall include the ability to "weight" the individual analog values so that the function output can be biased as necessary to achieve proper control.
6. Reset Function: This function shall develop an AO based on up to two AIs and one operator specified reset schedule.

7. Cooling/Heating Operation Program: Software shall be provided to change, either automatically or on operator command, the operating parameters, monitoring of alarm limits, and start-stop schedules for each mechanical system where such a change from cooling to heating and vice versa is meaningful. The software shall provide commands to application programs to coordinate cooling or heating mode operation. Software shall automatically switch facilities from cooling to heating, and vice versa, based on schedules or temperatures. All HVAC equipment and systems shall be assigned to the program.

I. Command Priorities: A scheme of priority levels shall be provided to prevent interaction of a command of low priority with a command of higher priority. The system shall require the latest highest priority command addressed to a single point to be stored for a period of time longer than the longest time constraint in the on and off states, insuring that the correct command shall be issued when the time constraint is no longer in effect or report the rejected command. Override commands entered by the operator shall have higher priority than those emanating from applications programs.

J. Resident Application Software: The Contractor shall provide resident applications programs to achieve the sequences of operation, parameters, constraints, and interlocks necessary to provide control of the systems connected to the DDC system. Application programs shall be resident and shall execute in the DDC, and shall coordinate with each other, to insure that no conflicts or contentions remain unresolved. The Contractor shall coordinate the application programs specified with the equipment and controls operation, and other specified requirements. A scheme of priority levels shall be provided to prevent interaction of a command of low priority with a command of higher priority. The system shall require the latest highest priority command addressed to a single point to be stored for a period of time longer than the longest time constraint in the ON and OFF states, insuring that the correct command shall be issued when the time constraint is no longer in effect or the rejected command shall be reported. Override commands entered by the operator shall have higher priority than those emanating from application programs.

1. Program Inputs and Outputs: The Contractor shall select the appropriate program inputs listed for each application program to calculate the required program outputs. Where the specific program inputs are not available, a "default" value or virtual point appropriate for the equipment being controlled and the proposed sequence of operation shall be provided to replace the missing input, thus allowing the application program to operate. AIs to application programs shall have an operator adjustable deadband to preclude short cycling or hunting. Program outputs shall be real analog or digital outputs or logic (virtual) points as required to provide the specified functions. The Contractor shall select the appropriate input and output signals to satisfy the requirements for control of systems as shown.
2. DDC General Conditions: The Contractor shall provide software required to achieve the sequences of operation, parameters, constraints, and interlocks shown. Application software shall be resident in the DDC in addition to any other required software. In the event of a DDC failure, the controlled equipment shall continue to function in the failure mode shown.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION CRITERIA

A. HVAC Control System: the HVAC control system shall be completely installed and ready for operation. Dielectric isolation shall be provided where dissimilar metals are used for connection and support. Penetrations through and mounting holes in the building exterior shall be made watertight. The HVAC control system installation shall provide clearance for control system maintenance by maintaining access space between coils, access space to mixed-air plenums, and other access space required to calibrate, remove, repair, or replace control system devices. The control system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.

B. Software Installation: Software shall be loaded for an operational system, including databases for all points, operational parameters, and system, command, and application software. The Contractor shall provide original and backup copies of source, excluding the general purpose operating systems and utility programs furnished by computer manufacturers and the non-job-specific proprietary code furnished by the system manufacturer, and object modules for software on each type of media utilized, within 30 days of formal government acceptance. In addition, a copy of individual floppy disks of software for each DDC panel shall be provided.

C. Device Mounting Criteria: Devices mounted in or on piping or ductwork, on building surfaces, in mechanical/electrical spaces, or in occupied space ceilings shall be installed in accordance with

manufacturer's recommendations and as shown. Control devices to be installed in piping and ductwork shall be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements shall not be used except as specified.

D. Wiring Criteria: Wiring external to control panels, including low-voltage wiring, shall be installed in metallic raceways. Nonmetallic-sheathed cables or metallic-armored cables may be installed in areas permitted by NFPA 70 wiring shall be installed without splices between control devices and DDC panels. Instrumentation grounding shall be installed as necessary to prevent ground loops, noise, and surges from adversely affecting operation of the system. Ground rods installed by the contractor shall be tested as specified in IEEE STD 142. Cables and conductor wires shall be tagged at both ends, with the identifier shown on the shop drawings. Electrical work shall be as specified in Section 16415A electrical work, interior and as shown.

3.02 CONTROL SYSTEM INSTALLATION

A. DDC Hardware: DDC Hardware shall be installed in an enclosure. Where multiple pieces of DDC Hardware are used to execute one sequence, all DDC Hardware executing that sequence shall be on a local control bus containing that DDC Hardware only and connected to another local control bus via an ANSI-709.1 Router or ANSI-709.3 repeater as specified.

B. Local Display Panel (LDP): Local Display Panels shall be installed in each mechanical room containing an air handler and shall provide SNVT inputs for display and outputs for adjusting SNVT values as shown on the Points Schedule. Multiple LDPs installed in the same mechanical room shall be co-located and clearly labeled indicating which SNVTs they provide access to.

C. Gateways: Gateways may be used for communication with non-ANSI/EIA-709.1 control hardware subject to all of the following limitations:
1. Each gateway shall communicate with and perform protocol translation for non-ANSI/EIA-709.1 control hardware controlling one and only one package unit.
2. Non-ANSI/EIA-709.1 control hardware shall not be used for controlling built-up units.
3. The non-ANSI/EIA-709.1 control hardware shall not perform system scheduling functions.

D. Network Interface Jack: A standard network interface jack shall be provided within 3m (10ft) of each node on the control network except terminal unit controllers with hardwired thermostats. For terminal unit controllers with hardwired themostats, the network interface jack should shall be located at the thermostat, but may be provided within 3m (10ft) of the node. If the network interface jack is other than an 1/8inch phone jack, Contractor shall provide an interface cable with a standard 1/8inch phone jack on one end and a connector suitable for mating with installed network interface jack on the other. No more than one type of interface cable shall be required to access all network interface jacks. Contractor shall furnish 1interface cable.

E. Damper Actuators: Actuators shall not be mounted in the air stream. Multiple actuators operating a common damper shall be connected to a common drive shaft. Actuators shall be installed so that their action shall seal the damper to the extent required to maintain leakage at or below the specified rate and shall move the blades smoothly.

F. Local Gauges for Actuators: Pneumatic actuators shall have an accessible and visible receiver gauge installed in the tubing lines at the actuator as shown.

G. Room Instrument Mounting: Room instruments , such as wall mounted thermostats, shall be mounted 1.5 m above the floor unless otherwise shown. Temperature setpoint devices shall be recess mounted.

H. Freezestats: For each 2 square meters of coil face area, or fraction thereof, a freezestat shall be provided to sense the temperature at the location shown. Manual reset freezestats shall be installed in approved, accessible locations where they can be reset easily. The freezestat sensing element shall be installed in a serpentine pattern.

I. Averaging Temperature Sensing Elements: Sensing elements shall have a total element minimum length equal to 3 m per square meter of duct cross-sectional area.

J. Foundations and Housekeeping Pads: Foundations and housekeeping pads shall be provided for the HVAC control system air compressors.

K. Duct Static Pressure Sensing Elements and Transmitters: The duct static pressure sensing element and transmitter sensing point shall be located at 75% to 100% of the distance between the first and last air terminal units.

L. Indication Devices Installed in Piping and Liquid Systems: Gauges in piping systems subject to pulsation shall have snubbers. Gauges for steam service shall have pigtail fittings with cock. Thermometers and temperature sensing elements installed in liquid systems shall be installed in thermowells.

3.03 CONTROL SEQUENCES OF OPERATION: See Control Drawings

3.04 BALANCING, COMMISSIONING, AND TESTING

A. CONTROLLER TUNING: The Contractor shall tune each controller in a manner consistent with that described in the ASHRAE Hdbk. Tuning shall consist of adjustment of the proportional, integral, and where applicable, the derivative (PID) settings to provide stable closed-loop control. Each loop shall be tuned while the system or plant is operating at a high gain (worst case) condition, where high gain can generally be defined as a low-flow or low-load condition. Upon final adjustment of the PID settings, in response to a change in controller setpoint, the controlled variable shall settle out at the new setpoint with no more than two (2) oscillations above and below setpoint. Upon settling out at the new setpoint the controller output shall be steady. With the exception of naturally slow processes such as zone temperature control, the controller shall settle out at the new setpoint within five (5) minutes. The contractor shall return the controller to its original setpoint and shall record and submit the final PID configuration settings with the O&M manual and on the associated Points Schedule.

3.05 START-UP AND START-UP TEST

A. The Contractor shall perform the following startup tests for each control system to ensure that the described control system components are installed and functioning per this specification.
   1. General: The Contractor shall adjust, calibrate, measure, program, configure, set the time schedules, set alarms, and otherwise perform all necessary actions to ensure that the systems function as described in the sequence of operation and other contract documents.
   2. Systems Check: An item-by-item check shall be performed for each HVAC system;
      a. Step 1 - System Inspection: With the system shut down, it shall be verified that power and main air are available where required and that all output devices are in their failsafe and normal positions. Each local display panel and, where applicable, each OWS shall be inspected to verify that all displays indicate shutdown conditions.
      b. Step 2 - Calibration Accuracy Check: With the system shut down, an accuracy check of the calibration of each HVAC control system sensing element and transmitter shall be performed by comparing each local display panel and, where applicable, each OWS readout to the actual value of the variable measured at the sensing element and transmitter or airflow measurement array location. Digital indicating test instruments shall be used, such as digital thermometers, motor-driven psychrometers, and tachometers. The test instruments shall be at least twice as accurate as the specified sensing element-to-DDC system readout accuracy. The calibration of the test instruments shall be traceable to National Institute of Standards and Technology standards.
      c. Step 3 - Calibration Accuracy Check: With the system running, the calibration accuracy check procedure from step 2 shall be repeated. The step 2 and 3 calibration checks shall verify that the sensing element-to-DDC system readout accuracies at two operating points (shutdown and running) are within the specified product accuracy tolerances. If not, the device shall be recalibrated or replaced and the two-point calibration accuracy check repeated.
      d. Step 4 - Actuator Range Check: With the system running, a signal shall be applied to each actuator through the DDC Hardware controller. Proper operation of the actuators and positioners for all actuated devices shall be verified and the signal levels shall be recorded for the extreme positions of each device. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. Where applicable, it shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

3. Weather Dependent Test: Weather dependent test procedures that cannot be performed by simulation shall be performed in the appropriate climatic season. When simulation is used, the actual results shall be verified in the appropriate season.
4. Two-Point Accuracy Check: A two-point accuracy check of the calibration of each HVAC control system sensing element and transmitter shall be performed by comparing the DDC system readout to the actual value of the variable measured at the sensing element and transmitter or airflow measurement station location. Digital indicating test instruments shall be used, such as digital thermometers, motor-driven psychrometers, and tachometers. The test instruments shall be at least twice as accurate as the specified sensing element-to-DDC system readout accuracy. The calibration of the test instruments shall be traceable to National Institute Of Standards And Technology standards. The first check point shall be with the HVAC system in the shutdown condition, and the second check point shall be with the HVAC system in an operational condition. Calibration checks shall verify that the sensing element-to-DDC system readout accuracies at two points are within the specified product accuracy tolerances. If not, the device shall be recalibrated or replaced and the calibration check repeated.

Test Report: Upon completion of the Start-Up Test, the contractor shall prepare and submit a Start-Up and Testing Report documenting the results of the tests performed and certifying that the system is installed and functioning per this specification, and is ready for the Performance Verification Test (PVT).

3.06 PERFORMANCE VERIFICATION TEST (PVT)

A. PVT Procedures: The performance verification test procedures shall explain, step-by-step, the actions and expected results that will demonstrate that the control system performs in accordance with the sequences of operation, and other contract documents. The PVT shall include a one-point accuracy check of each sensor. The PVT procedure shall describe a methodology to measure and trend the Network Bandwidth Usage on the backbone and compare it to the Bandwidth Usage Calculation submittal. A control system performance verification test equipment list shall be included that lists the equipment to be used during performance verification testing. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

B. PVT Execution: The Contractor shall demonstrate compliance of the control system with the contract documents. Using test plans and procedures previously approved by the Government, the Contractor shall demonstrate all physical and functional requirements of the project. The performance verification test shall show, step-by-step, the actions and results demonstrating that the control systems perform in accordance with the sequences of operation. The performance verification test shall measure and trend the Network Bandwidth Usage and compare it to the Bandwidth Usage Calculation submittal. The performance verification test shall not be started until after receipt by the Contractor of written permission by the Government, based on Government approval of the Start-Up and Testing Report and completion of balancing. The tests shall not be conducted during scheduled seasonal off periods of base heating and cooling systems.

C. PVT Report: Contractor shall prepare a PVT report documenting all tests performed during the PVT and their results. The PVT report shall include all tests in the PVT Procedures and any other testing performed during the PVT. Failures and repairs shall be documented with test results.

3.07 POSTED AND PANEL INSTRUCTIONS

A. Posted and Panel Instructions, showing the final installed conditions, shall be provided for each system. The posted instructions shall consist of laminated half-size drawings and shall include the control system schematic, equipment schedule, sequence of operation, wiring diagram, communication network diagram, and valve and damper schedules. The posted instructions shall be permanently affixed, by mechanical means, to a wall near the control panel. Panel instructions shall consist of laminated letter-size sheets and shall include a Routine Maintenance Checklist and as-built configuration check sheets. Panel instructions and one copy of the Operation and Maintenance Manuals, previously described herein, shall be placed inside each control panel or permanently affixed, by mechanical means, to a wall near the panel.

3.08 TRAINING

A. Training Course Requirements: A training course shall be conducted for up to 10 operating staff members, 2 classes with 5 persons in each class, designated by the Contracting Officer in the maintenance and operation of the system, including specified hardware and software. The training period, for a total of 40 hours of normal working time, shall be conducted immediately after successful completion of the performance verification test (PVT). The training course shall be conducted at the project site. Audiovisual equipment and 10 sets of all other training materials and supplies including 5 instructional laptops per session shall be provided. A training day is defined as 8 hours of classroom instruction, including two 15 minute breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.

B. Training Course Content: For guidance in planning the required instruction, the Contractor shall assume that attendees will have a high school education or equivalent, and are familiar with HVAC systems. The training course shall cover all of the material contained in the Operating and Maintenance Instructions, the layout and location of each HVAC control panel, the layout of one of each type of unitary equipment and the locations of each, the location of each control device external to the panels, the location of the compressed air station, preventive maintenance, troubleshooting, diagnostics, calibration, adjustment, commissioning, tuning, and repair procedures. Typical systems and similar systems may be treated as a group, with instruction on the physical layout of one such system. The results of the performance verification test and the calibration, adjustment and commissioning report shall be presented as benchmarks of HVAC control system performance by which to measure operation and maintenance effectiveness

C. Follow-up training for a total of 24 hours (3 8-hour days) shall be provide six months after the initial training. This training will concentrate on facility control problems & the programming solutions. It will also cover refresher training covering troubleshooting, diagnostics, calibration, adjustment, and tuning.

END OF SECTION

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DIVISION 16 - ELECTRICAL

16A SCOPE: This section covers the requirements for installation of electrical equipment for two new HVAC units. See drawings and this specification for further details.

16B CODES: The following publications and regulations, in effect on the date of the invitation for bids or request for proposals, form a part of this specification and are applicable to the extent specified herein:

Building Officials and Code Administrators International	Michigan Basic Building Code & Mechanical Code Latest Editions
Sheet Metal and Air Conditioning Contractors National Association	HVAC Duct Construction Standards, Metal and Flexible, Latest Edition
National Fire Protection Association	National Electrical Code, Latest Edition
(Manufacturer of Installed Equipment)	Equipment Installation Instructions, Applicable Edition for Specified Approved Model Number

The rules and regulations of the local utility companies providing service and local governing body rules and regulations.

16C CONDUITS:

1. Insulated conductors shall be installed in rigid galvanized steel conduit.

2. Minimum size of conduit shall be 3/4", unless otherwise noted on the drawings. Power conductors for new A/C units shall be in 1 ¼" minimum size conduit. Each conduit run shall be complete before any conductors are drawn in.

3. Exposed conduit shall be installed parallel to or at right angles with the lines of the building unless shown otherwise. Field bends shall be avoided where possible and, where necessary, shall be made with approved hickey or conduit-bending device. Radius of field bends shall not be less than 10 times the inside diameter of the conduit.

4. Terminal electrical connections to motors or motor-driven equipment shall be made with a 12" minimum length of 1 ¼" flexible metallic conduit. Such conduit shall be approved by Underwriters Laboratories. The flexible conduit shall have a liquid tight jacket of plastic, synthetic rubber, or neoprene extruded overall. Connections between rigid conduit, conduit fittings, and other junctions and the flexible conduit shall be made with fittings recommended by the liquid tight flexible metal conduit manufacturer.

5. The use of non threaded-type fittings will not be permitted with rigid conduit. All rigid conduit terminals requiring locknuts shall be furnished with double locknuts and insulated bushings rated 150°C.

6. All suspended conduits shall be rigidly supported from the structure by means of approved conduit hangers or clamps firmly anchored in place and spaced at intervals not to exceed 10 feet in accordance with minimum requirements of NEC.

16D CONDUCTORS:

1. Conductors shall be copper, type THWN/THHN rated at 600 volts. Minimum size of wire shall be as shown on the drawings and not less than #1 AWG for A/C unit power conductors and not less than #2AWG for A/C unit ground conductors.

2. Sheet Metal Ductwork. Any required new sheet metal ductwork shall be constructed of minimum of 20-gauge galvanized steel sheets. Ducts, unless otherwise approved, shall be straight and smooth on the inside, with joints neatly finished. All edges and slips shall be hammered down to leave a smooth interior duct finish.

A. Joint Connections. Joint connections shall be standing S, or bar reinforced.

B. Joints for Ducts. Joints for ducts shall be made substantially airtight, and no dust marks from air leaks shall show at duct joints.

C. Laps at the Joints for Duct System. Laps at the joints for the duct system shall be made in the direction of air flow. Butt, punch, or bolt connection in standing seams shall be spaced at fixed centers no greater than 6" apart.

D. Coating for Ducts The entire exterior surface of all exterior ductwork shall be coated with two coats of duct sealer. Sealer specifically designed for duct weatherproofing shall be used and applied per manufacturer's recommendations. Total coating thickness shall be a minimum of 10 mils.

3. Insulation. All exterior ductwork shall be internally insulated with 2" (minimum R=8) of simi-rigid bonded board conforming to NFPA 90A/90/B. An adhesive coating applied to achieve a minimum 90% coverage and mechanical fasteners installed according to manufacturer's recommendations #2 AWG for A/C unit ground conductors.

2. All wiring, including feeders, shall be color coded. Three-phase color coding (black, red, and blue) shall be continued through the system to the point of utilization. In no case shall green be used for other than equipment grounding conductor, nor white for other than the neutral conductor.

3. No splices or joints shall be made in either feeders or branch circuits except at outlets, accessible junction boxes, or accessible raceways. Joints in circuit wiring shall be made mechanically and electrically secure and made with solderless connectors. Unless properly insulated by the connectors, all joints shall be taped with plastic tape in a manner that shall make their minimum insulation equal to the insulation of the conductors.

16E GROUNDING: Equipment Grounding Conductor. All metallic non-current carrying parts of electrical equipment shall be grounded with an equipment grounding conductor whether or not shown on the drawings. The equipment grounding conductor shall be green insulated copper conductor unless otherwise indicated. If this conductor is not sized, or shown on the drawings, it shall be sized in accordance with the applicable sections of the National Electrical Code and in no case shall it be smaller than #8 AWG. The equipment grounding conductor shall

be connected to the grounded conductor (neutral) only at the main service disconnect. The equipment grounding conductor shall be installed in the same conduit as its related branch and feeder conductors and shall be connected to the ground bus in the branch or distribution panel board.

Second Floor Outside Air Intake Hoods to Be Extended Down to Additional 24 Inches with 16 Ga Sheet Metal